

PRACTICAL

SEPTEMBER 1986 · £1.25

ELECTRONICS

SCIENCE AND TECHNOLOGY

TALKING
INFRA-RED

ANALOGUE
HOBBY BUS

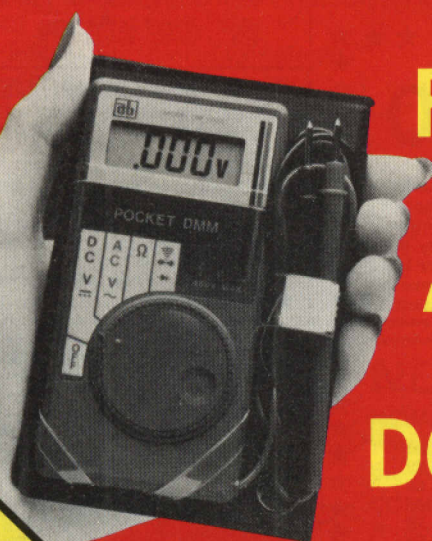
RS232 OPTO
DATA LINK

PRO-AM CAD
REVIEW

NEW SERIES . . .



. . . EXPERIMENTAL ELECTRONICS



FAMILIAR FAMILIES

CMOS and TTL logic update

A RADIO MYSTERY

Mind control by the Soviets?

DC SIGNAL CONTROL

— Of analogue signal functions

EXCLUSIVE SPECIAL
MULTIMETER
OFFER!

THE SCIENCE MAGAZINE FOR SERIOUS

ELECTRONICS AND COMPUTER ENTHUSIASTS

PROJECTS TO BUILD

IR COMMUNICATOR by The Prof.

The first in our series of experimental projects investigates the techniques and applications of infra-red light for communication purposes.

HOBBY BUS DtoA/AtoD by Ray Stuart

From the author of the popular Bytebox project comes a universal analogue board for the PE Hobby Bus. Simply plug it in, drive it from any computer and talk to the real world – and listen!

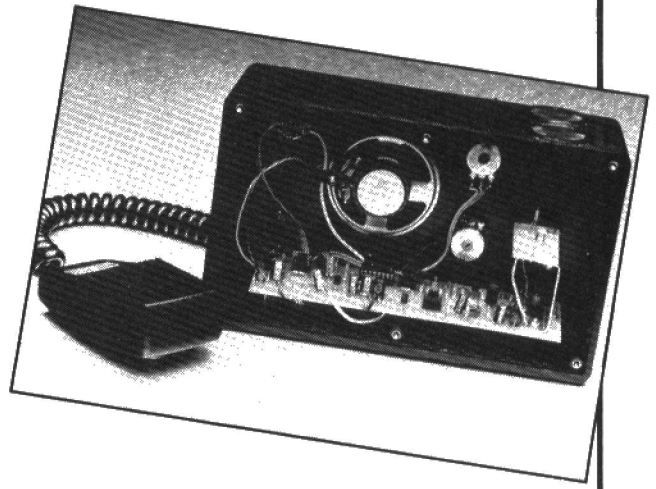
FIBRE OPTIC DATA LINK by R.A. Penfold

An extremely useful computer add-on project which can reduce program crashes due to mains borne interference and RFI. (Part Two – next month).

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SPECIAL FEATURES

SHOESTRING CAD-CAM by R.A. Penfold

Following on from our in-depth look at CAE, this month we take a close look at the CAD-CAM software packages available to the hobbyist (and professional). It will make a welcome change to Space Invaders and the like.

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Despite the ever increasing use of digital electronics in audio systems, analogue control is still extremely important and widely used. This article is full of useful circuits and ideas for d.c. control.

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FAMILIAR FAMILY FUNCTIONS by R. A. Penfold

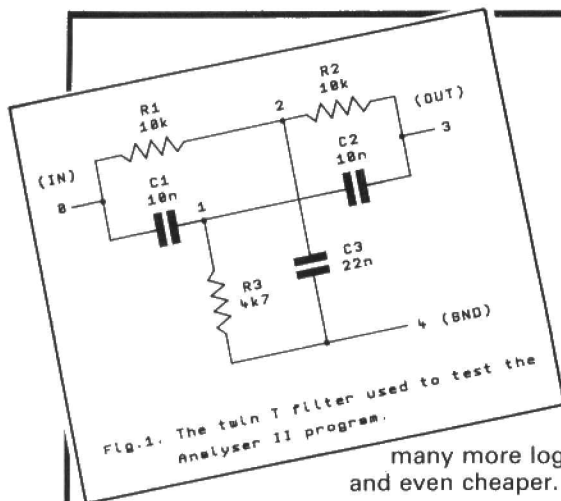
Many of the projects featured in PE employ standard TTL, LS or CMOS devices. However, over the last few years, many more logic families have been introduced which are faster, more efficient and even cheaper. This article lead you through the 'logic jungle'.

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THE FEATHERLESS WOODPECKER by Simon Battman

A true modern day mystery story about possibly the most powerful radio transmitter in the universe which operates behind the Iron Curtain – but why?

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many more logic families have been introduced which are faster, more efficient and even cheaper. This article lead you through the 'logic jungle'.

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EXPERIMENTAL ELECTRONICS by The Prof

This is the first in our new series dealing with the less common aspects of electronic design. This month we look at IR communication.

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SPACEWATCH by Dr. Patrick Moore OBE

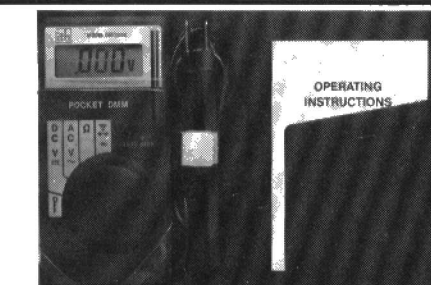
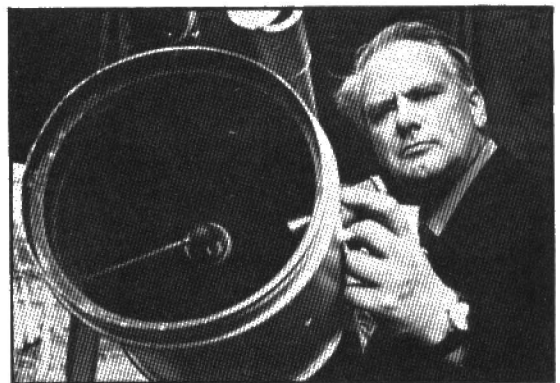
The astronomy page plus the sky this month. This month – powerful magnetic fields – and more!

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NEWS REVIEWS AND VIEWS

NEWS AND MARKET PLACE

Whats New, Whats happening and Whats to come in the world of Hobby and Industrial electronics.

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POCKET MULTIMETER REVIEW and special offer

One of the smallest digital multimeters available is offered to PE readers at an exclusive discount price.

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THE SCIENCE MAGAZINE FOR SERIOUS ELECTRONICS ENTHUSIASTS

Editor: Richard Barron

Consultant

Editor—Electronics:

R. A. Penfold

Consultant

Editor—Computing:

Nick Hampshire

Editorial Assistant:

Mary-Ann Hubers

Advertisement Manager:

Alfred Tonge

Publisher: Angelo Zgorelec

Readers' Enquiries

All editorial correspondence should be addressed to the editor and any letters requiring a reply should be accompanied by a stamped addressed envelope. Please address editorial correspondence to: **Practical Electronics, 16 Garway Rd., London W2 4NH. Tel. 01-727 7010**

We regret that lengthy technical enquiries cannot be answered over the phone.

Advertisements

All correspondence relating to advertisements, including classified ads, should be addressed to: **The advertisement manager, Practical Electronics, 25 Glenhurst Avenue, Bexley, Kent DA5 3HQ. Tel. (0322) 521069.**

PE Services

Practical Electronics offers a wide range of services to readers including: p.c.b.s, books, subscriptions, back numbers, and software listings. However, due to increased administration costs we can no longer provide photocopies of articles over three years old. Also the availability of back numbers is rapidly declining.

In order to avoid disappointments, in the future, we suggest that you take out a subscription. Not only will you avoid missing an issue but you will also save money and in most cases receive your copy before it is in the local newsagents.

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MY BIT AT THE BEGINNING

Over the last couple of months I have been taking a close look at the results of our 1986 readers' survey. These results, together with the many readers' letters which have come in to our editorial office, have enabled me to formulate plans for the future of PE to suit your needs.

From your comments, it seems that we are not doing too many things wrong but there are one or two slight changes which need to be made. By popular demand, next month, we are re-introducing printed p.c.b. designs for constructional projects as many readers are now producing their own p.c.b.s. With our better quality paper which was introduced in the April issue, p.c.b. manufacture from published designs should prove to be much more satisfactory. We will of course continue with our p.c.b. service.

Whilst continuing with an excellent range of constructional projects, we have lots of interesting and informative features in the pipeline. It seems that with our increasing attention to science and technology, we are attracting many readers who build fewer projects but are nevertheless interested in our hobby.

I would like to take this opportunity to thank all those who returned completed surveys, and especially those responsible for the following answers.

Q. *How much do you spend on components for your hobby each year?* **A.** *Over £5,000.*

Q. *How long have you been interested in electronics?* **A.** *74 years.*

Q. *Which newspaper do you read regularly?* **A.** *Breakfast Time TV.*

The winner of our competition was Mr Richard Paul Horsley of Sheffield, who guessed the exact number of replies to our survey. A cheque for £50 is on its way. Those of you who guessed three million were way off.

Richard Barron

DID YOU KNOW

There are now over 12,000 One-To-One electronic mail subscribers in the UK alone.

1986 will see the first ever decline in the output of Japanese VCRs (Benn Electronics).

One of our readers claims to spend £5,000 per year on electronic components.

OUR OCTOBER 1986 ISSUE WILL BE ON SALE FRIDAY, SEPTEMBER 5th, 1986 (see page 31)

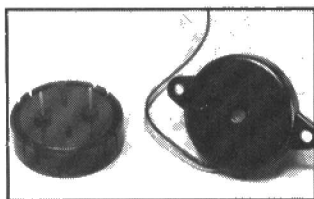
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WHAT'S NEW . . .

Noise . . .

Most electronic devices and projects have either sound or light outputs. They wouldn't be any fun otherwise! For audible tones for supervisory or alarm signals, a range of four piezoelectric transducers are now available from Quantelec.

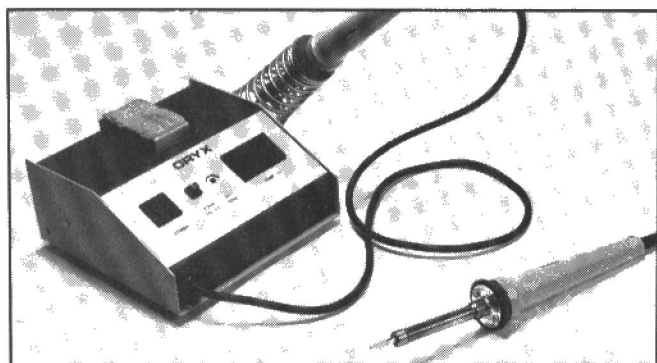
The range includes p.c.b. mounting and free standing versions, all of which can operate with voltages up to 30Vpk-to-pk. Depending on the device, operating frequencies are in the range, 2 to 6KHz.



Multimeter Chip

Lascar Electronics, which specialises in digital displays, has just announced the availability of an extremely compact 4½ digit liquid crystal display multimeter. It takes the form of a 28-pin d.i.l. package which may be plugged directly into a suitable d.i.l. socket. It comes complete with 1/8 DIN snap-in bezel for panel mounting.

The meter features auto-zero, auto polarity, programmable decimal point and 200mV f.s.d. To set it up for a particular function, on-card links are made available for quick programming.



Sophisticated Hobbyists

Oryx now produces a high-tech soldering station for the hobbyist – at a competitive price level (£84 inc VAT and P&P). They say the recommended retail price is £112. The soldering station can be purchased direct

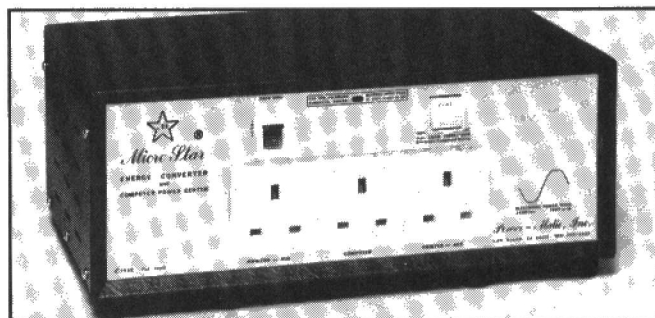
Why?

GCA now stocks Bussman type GFNQ fibre tube fuses for immediate delivery. Why they have to get our attention by putting them on a US dollar bill, I don't know. The fuses are quoted as being 'high reliability' types, so maybe they are comparing them to the reliability of the US dollar. Anyway, it makes an interesting photo.



Whoops – Dropped It

Kaise Ltd., a UK distributor of Eagle International Products, now has two 'drop-proof' multimeters in its range of test equipment. The two meters are said to be able to withstand a drop of one metre. Kaise does not claim that it can prevent the meters from being dropped and the guarantee does not apply to meters dropped 101cm.



PFC For PCs

There are many units now on the market designed to protect personal computers from mains-borne interference such as transients, but the new MicroStar power conditioning unit from Powerline can also reduce power consumption.

Power consumption is achieved by power factor correction (PFC). The Microstar is said to improve the power factor on most switched-mode or linear computer power supplies from 0.7 to almost unity. This should reduce peak stresses and heat dissipation within the PC's power supply.

CATALOGUE CASE BOOK

During the last month we have received the following catalogues, information sheets and bulletins:

A range of price sheets from Crofton Electronics covering a wide range of **Electronic components and TV Equipment**. Details from: Crofton Electronics, 35 Grosvenor Road, Twickenham, Middlesex. Tel: 01-891 1923.

Outline details of a range of **RFI suppression chokes** is now available from: Shaffner EMC Ltd., Headley Park Area 10, Headley Road East, Woodley, Reading, Berks. Tel: (0734) 697179.

The Bussman range of international **fuseholders** are detailed in a new shortform catalogue from: GCA Electronics Ltd., Unit 2, Great Haseley, Oxfordshire. Tel: (08446) 8861.

Semiconductor products range catalogue from: Iskra Ltd., Redlands, Coulsdon, Surrey. Tel: 01-668 7141.

WHAT'S NEW . . .

POINTS ARISING

FIBRE OPTIC DATA LINK

Sorry, this project could not be included in the August Issue due to lack of space.

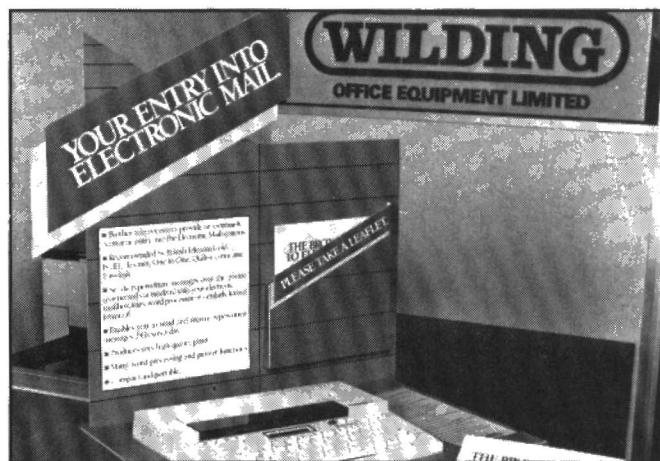
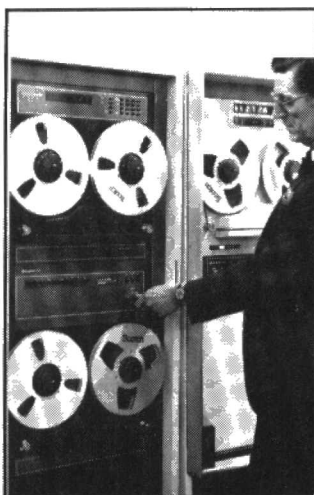
SBC PART 2

ADDED TO JUNE 1986 MR

The SBC will be concluded in next month's issue. There will be no constructional details as others are compatibility problems with the design.

Children And Even Infants Can Be Supplied

Frazer-Nash is teaming up with Ogle Design to produce human-surrogate dummies for quantitative assessment of likely bodily discomfort or damage under controlled test conditions. They are fitted with various electronic sensors which can faithfully record the effects on human organs such as the heart-lung complex, under collision or crash conditions. The dummies have realistic skeletons and correctly proportioned body weight. Normally adult size dummies are supplied but children and even infants are available.



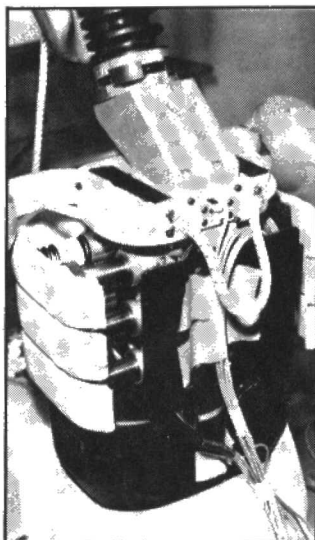
Big Brother Is Watching You

Or maybe listening. Brother, the electronic equipment manufacturer, has just put a complete electronic mail starter kit on the market. It looks like a portable electronic typewriter or personal computer, but is designed purely for electronic mail purposes. It features integral modem, l.c.d. and keyboard, and comes complete with a One-To-One electronic mail box, individual password and identity number.

Micro Training

A new programmable controller training system from LJ Electronics, the PC2000, has been specifically designed for trainee technicians. It features easy access to the internal microprocessor boards and I/O modules as well as a range of standard features expected on a system of this nature.

Unlike some systems, backup is provided in the form of 4-day training courses intended for lecturing and training staff.



Tape Twist

Gentlemen in the City have never had any real trust in each other, something which has become more apparent in recent times. It is now common practice to record all dealings and transactions which take place over the phone. Dictaphone, a company which specialises in dictating and recording machines, has made further additions to its Veritrac range of products. Veritrac machines are able to record radio and telephone conversations on a tape track together with the date and time. They can now record up to 60 channels.



Nutcracker

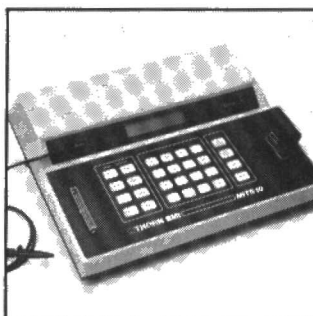
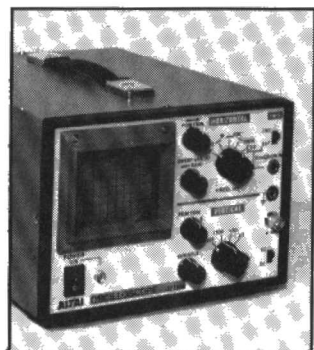
Thorn EMI calls its latest 8-bit microprocessor hardware debugging tool the Nutcracker. The Nutcracker is designed for system development, board production and engineering maintenance applications.

Test sequences can be programmed and stored in non-volatile memory cartridges for ATE applications. Tests are selected via main option keys on

the front panel. Connection to the target system is made via a universal 40-pin lead which plugs into the vacant position left by the microprocessor of the system under test.

Scope for Savings

A portable oscilloscope for less than £150 + VAT is now available from Semiconductor Supplies Ltd. It has a three inch screen and vertical sensitivity of 10mV/6mm division. Their press-release announcing the product said "It is particularly suitable for observing the waveform of electronic signals". Gosh - that's unusual!



NEWS . . .

WHAT'S HAPPENING . . .

A closer look at what is happening in the electronics world plus what present developments might bring in the future?

POCKET BARGAIN

A truly pocketable digital multimeter has just been launched in the UK by AB European Marketing Division. Not much bigger than a credit card, it is the smallest test instrument, of its kind, that I have seen. Measuring only 108mm x 54mm x 8mm it weighs a mere 80gms and comes complete with its own plastic wallet, permanently attached test probes and operating instructions.

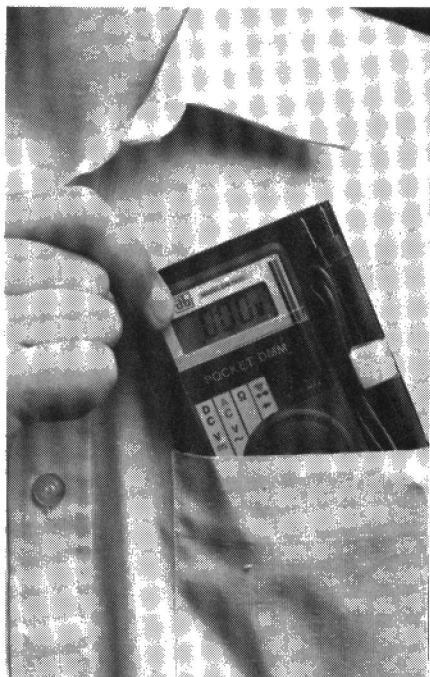
It is manufactured in Japan to the highest standards, unlike some similar products from the same part of the world. In fact to fall in line with AB's policy it had to pass stringent tests in a BS9000/CECC approved test house. It passed with flying colours and showed good performance in extreme conditions unlikely to be experienced in practical use. Another pocket multimeter tested in the same test house failed. AB decided not to market it. The DM1000 offers auto-ranging for all functions including d.c. voltage, a.c. voltage and ohms ranges. In addition, a continuity and diode test facility is included. The complete specification is shown in our special offer on page 43.

Until I actually saw the product, first hand, I had certain reservations about the manufacturer's claims regarding the ruggedness and quality. These were, however, soon dispelled. Despite its size, it looks and performs well and passed my personal 'clumsy me' test.

Perhaps, more than anything else, the attraction of this meter is its portability. It really does just slip into your pocket, ready for use at any time. Operation could not be simpler—there is just one dial which selects any range and acts as an on/off switch. The probes do not have to be plugged in and should the wrong range be selected, an internal protection circuit takes good care of the problem.

Admittedly, at a recommended price of £24.60 plus VAT and p&p, other electronic multimeters offer more facilities for less money. However, as I have already said, its quality, ease of use, compactness and portability make it an ideal general purpose multimeter for anyone involved in radio, computers, TV or general electronics.

See our special offer, page 43.



One of the main functions of the Centre, which comprises training facilities, laboratories and residential blocks for teachers, is converting buses into mobile high technology teaching centres for local authorities.

The Carlton complex is British School Technology's second centre. It also operates from a site at Trent Polytechnic. BST was created in 1984 to support the teaching of technology in schools. It receives funds from the Department of Trade and Industry and the Manpower Services Commission. "It is this unique partnership between government, industry and education that gives BST its strength and relevance," said the Secretary of State for Trade and Industry, Paul Channon, who opened the facility.

BST hopes to be self-financing by next year. It currently generates a large proportion of its own income. In addition to supplying mobile technology units (one-third of local education authorities have purchased or ordered units), BST offers training courses for technicians, a consultancy service for technological equipment for schools and local education authorities and help with developing curriculums.

In the two years of its existence, 85 per cent of local education authorities have used its service. By the end of this year, BST hopes to have retrained 7,000 teachers.

BST's expansion is an encouraging development, which will hopefully open up the world of technology to youngsters and produce some much-needed scientists and technicians for Britain.

Oxfam Needs Bright Sparks

Oxfam is looking for volunteers with electrical and electronic skills to check electrical goods donated to its shops. The agency raised over £51 million for Third World Aid last year. A large part of that came from Oxfam's 750 shops, run by 25,000 volunteers.

But they reckon they lose hundreds of pounds of potential income because of a lack of volunteers who can properly check electrical goods that are donated for sale. If you fit the bill and want to devote some of your time and skills to this worthwhile cause, contact Faye Wark, Oxfam Freepost, London N12 9BR or ring 01-446 6888.

£4m Optic Orders

British Telecom International has already received orders worth £4,000,000 for its transatlantic optical fibre cable services on the planned TAT-8 link.

TAT-8 will be the eighth underwater telecommunications link between Europe and North America and the first transatlantic cable to employ optical fibre technology in which digital signals are carried as pulses of light along hair-thin strands of glass.

The US\$35 million cable will be able to carry up to 40,000 simultaneous telephone calls, trebling the capacity of all the existing transatlantic cable links. In addition to telephone calls, the cable will transmit data, text, fax, graphics and video.

TAT-8 is scheduled to come into service in June, 1988.

"The prompt response demonstrates the intensifying need for companies to plan the right mix of international communications services well in advance,"

said Mike Ford, Chief Executive of British Telecom International's Business Division.

British Airways, Barclays Bank and Mobil are among the companies who have placed orders.

"High-capacity, high-reliability transatlantic links will help us to improve all our customer service functions,"

said Jeff Maynard, British Airways' telecommunications general manager.

Let's Fly A Kite

The kitemark found on a wide range of goods in the high street celebrates its 60th birthday this year. Kitemarked and safety marked products indicate that goods are manufactured to certain quality and safety standards. However, it also means that the goods are manufactured to the BS 5750 quality system standard accepted by BSI. To highlight this, two new certification labels will appear on products which clearly state that they are certified products.

Welcome Development In Education

A new British School Technology Centre was opened at Carlton, Bedfordshire in June. The Centre's purpose is to encourage the teaching of technology in schools, a welcome development in light of the recent release of statistics showing a decline in the number of science graduates going into the teaching profession.

WHAT'S TO COME . . .

Belated Optical Awards

Three Dutch scientists were among 11 recipients of the Rank Prize Funds Awards recently presented in London. The three researchers, Dr P. Kramer, Mr G. Bouwhuis and Dr K. Compaan, all employees of Philips, were belatedly recognized for their research during the seventies which laid the basis for the optical recording and reading of information on a disc.

It was at the Philips research laboratories in Eindhoven that the three award-winners first devised the technique for recording image and sound signals on a disc in such a way that the information could be read without contact using laser light.

This led to developments in three different areas of application. Research was first devoted to the recording and reading of video images. The video disc (now known as LaserVision) first made its appearance in a public demonstration in 1972.

In the mid-seventies, the importance of the opto-electronic system for a new audio medium was recognized. Using the same technology it was made possible to record sixty minutes of music on a small disc, with the digital coding resulting in a very high quality sound. Compact discs have taken off in a dramatic way since their introduction on the market in 1983.

The original research of the three award-winners has led to a third application – the recording of digit information for the electronic office, offering tremendous possibilities for date and document registration.

In his speech of thanks Dr Kramer said, *"Ideas like an optical disc need a proper environment to grow: a large multi-disciplinary research organisation, expertise in a number of technological areas and a spirit of entrepreneurship, both technical and commercial. One needs also perseverance and some luck, because gambling is unavoidable. We did not need so much perseverance, because it was a nice, friendly and converging subject. And we had some luck."*

The Rank Funds were established in 1972 by the late Lord Rank. Since then awards have been presented to individual scientists who have achieved significant breakthroughs in the fields of opto-electronics and human and animal nutrition.

It's Just A Fluke

The new model 37 digital multimeter from Fluke is now available for around £190. It is designed to bridge the gap between versatile bench models and inexpensive but useful portables. This is achieved through keeping the circuitry compact, and including a built-in compartment for test lead, battery and tools.

As would be expected from a modern microprocessor based bench meter, a variety of functions are available which make it a very useful service tool. The l.c.d. digital display also incorporates a pseudo-analogue bar graph which is intended to simplify peaking or nulling operations.

Other useful facilities include max. and min. readings, touch-hold mode which captures readings and relative mode which only displays 'difference' readings.



CERTIFIED PRODUCT

Manufactured under a BS 5750 Quality System accepted by BSI



CERTIFIED PRODUCT

Manufactured under a BS 5750 Quality System accepted by BSI

FIRM CONTACT

Details of products, services and companies mentioned in News and Market Place can be obtained from the following sources:

Greenwood Electronics, Portman Road, Reading RG3 1NE.

Brother Computer Peripheral Division, Jones & Brother, Shepley St. Guide Bridge, Audenshaw, Manchester M34 6JD.

Powerline Electronics Ltd., 5 Nimrod Way, Elgar Road, Reading RG2 OEB

L. J. Electronics, Francis Way, Bowthorpe Industrial Estate, Norwich NR5 9JA.

Frazer-Nash Electronics Ltd., Randalls Way, Leatherhead, Surrey KT22 7TX.

GCA Electronics Ltd., Unit 2, Gt. Haseley Trading Estate, Gt. Haseley, Oxon OX9 7PE.

Thorn EMI Instruments Ltd., Archcliffe Road, Dover, Kent CT17 9EN.

Semiconductor Supplies International Ltd., Dawson House, 128/130 Carshalton Road, Sutton, Surrey SM1 4RS.

Eagle International, Unit 5, Royal London Estate, 29/35 North Acton Road, London NW10 6PE.

Quantelec Limited, 46 Market Square, Witney, Oxon OX8 6AL.

Dictaphone Company Ltd., Regent Square House, The Parade, Leamington Spa, Warwickshire CV32 4NL.

Lascar Electronics Ltd., Module House, Whiteparish, Salisbury, Wilts SP5 2SJ.

Department of Trade and Industry, 1 Victoria Street, London SW1H 0ET.

Oxfam, 724 High Road, Finchley, London N12 9QD.

Philips Electronic and Associated Industries Ltd., Arundel Great Court, 8 Arundel Street, London WC2R 3DT.

British Telecom, British Telecom Centre, Floor A3, 81 Newgate Street, London EC1A 7AJ.

AB European Marketing, Forest Farm Industrial Estate, Whitchurch, Cardiff CF4 7YS.

COUNTDOWN

If you are organising any electrical, computing, electronic, radio or scientific event, big or small, drop us a line. We shall be glad to include it here. Address details to Countdown, Practical Electronics, 16 Garway Road, London W2 4NH.

NOTE: some exhibitions detailed here are trade only. Please check details and dates before setting out, as we cannot guarantee the accuracy of the information presented here.

Milan Fair, Sept 4-8, Milan. (Trade only)

20th SIM-HI-FI-IVES, Sept 4-8, Milan. (A)

International Video and Consumer Electronics Show, Sept 4-8, Milan.

Farnborough International 1986, Sept 5-7, Farnborough. (B)

British Laboratory Week, Sept 23-25, Olympia. (C)

ITAME, Sept 23-25. (C)

Test and Transducer, Oct 28-30, Wembley Conference Centre. (E)

Audio '86, Nov 12-15, Olympia 2.

Instrumentation '87, Feb 25/26, Harrogate Exhibition Centre, March 25/26, Bristol, Crest Hotel.

(A) Segreteria Generale: 20149 Milano. ☎ 02/4815541.

(B) Society of British Aerospace Companies Ltd. ☎ 01-839 3231.

(C) Evan Steadman. ☎ 0799 26699.

(D) Imperial College. ☎ 01-589 5111.

(E) Trident International Exhibitions Ltd. ☎ (0822) 4671.

HOBBY BUS A/D & D/A BOARD

BY RAY STUART

The first add-on for the PE Hobby Bus provides both A to D and D to A facilities at a fairly low cost. The scope for experimentation, with this project, is enormous.

THERE are many occasions when, in order to communicate with real devices, computer systems have to deal with analogue values. For example, temperature is measured on a continuously variable scale rather than in discrete digital steps.

However, computers can respond to such signals by means of analogue to digital and digital to analogue converters. These devices cannot produce infinitely variable signals but approximate by producing signals consisting of a number of small steps. The system presented here is compatible with the Practical Electronics Hobby Bus and as such is designed to interface to 8-bit computers and microprocessors. Thus the system presented here converts analogue signals to 2^8 or 256 steps and vice versa.

The system converts both digital signals to analogue, and analogue signals to digital with an accuracy of better than 0.5% of full scale. In this design the range of the analogue to digital converter is 0 to 5 volts and that of the digital

to analogue converter is 0 to 2.55 volts. These figures represent resolutions of 20 millivolts and 10 millivolts respectively. In many applications it is necessary to measure and control more than one variable. To this end this design allows the host system to measure 16 analogue input voltages and produce 2 analogue output voltages.

ANALOGUE TO DIGITAL CONVERSION

There are many techniques that are used to convert analogue signals to digital representation. The successive approximation method, in common with many others, contains a digital to analogue converter whose output is compared with the analogue signal to be measured. The usual method is to set the digital to analogue converter with its input, and hence output, to zero and then increase it until the comparator detects that it is just higher than the analogue value being measured. The digital value supplied to the digital to analogue converter is then proportional to the input analogue value. This time taken by this type of conversion is dependent on the magnitude of the analogue signal; the smaller the signal the quicker the conversion.

In contrast, the successive approximation method always takes the same conversion time irrespective of the magnitude of the analogue signal. The technique relies on a chain of 256 resistors and a number of semiconductor switches, called a resistor ladder switch tree, as shown in Fig. 1. By suitably selecting the combination of switches, any one of the 256 reference voltages generated by the resistor chain can be selected.

Let us now consider the algorithm used for this method of conversion. SW1 and SW2 are used to select the upper or lower half of the resistor ladder voltage range. Thus the first step in the conversion technique is to determine if the input analogue signal is in the upper or lower half of the resistor chain range.

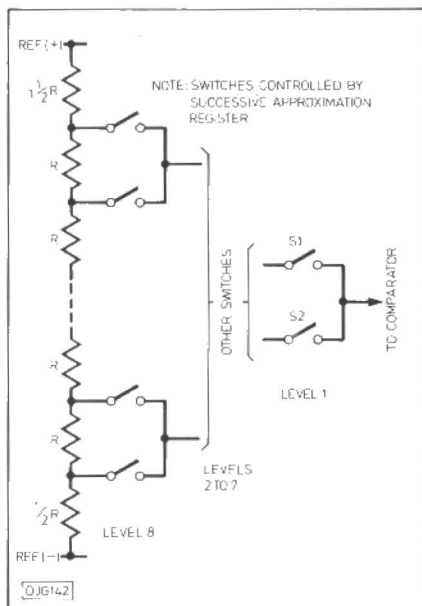


Fig. 1. Switch tree

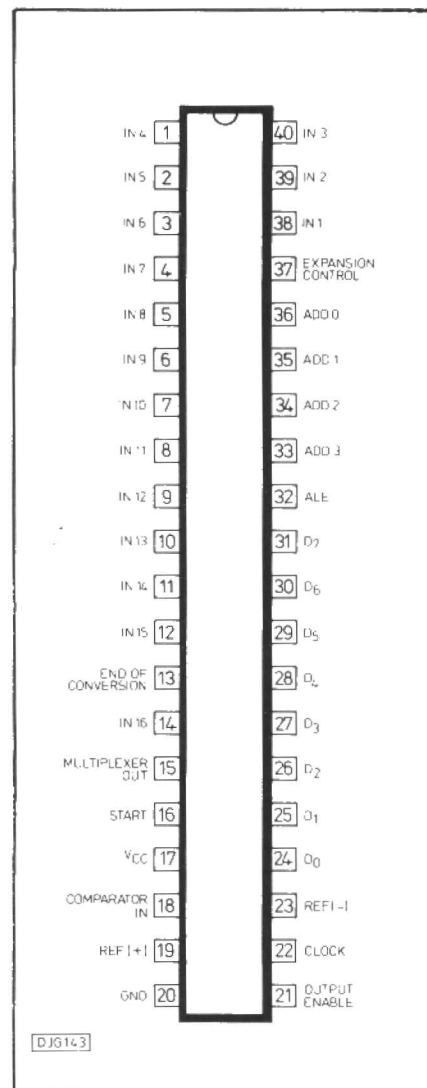


Fig. 2. ADC 0817

Thus half the possible values are eliminated in one step. Let us assume that it has been determined that the value lies in the lower half. The second step splits this into two further ranges and this process is repeated until the final value is determined.

It can be seen that there have to be eight switch levels in order to be able to select any one of the 256 reference voltages. Thus the switch pattern is the binary representation of the input analogue voltage, and the conversion time is the same whatever the value the input analogue voltage.

ANALOGUE TO DIGITAL CONVERTER CIRCUIT

As stated above, the design presented here allows 16 analogue voltages to be converted with a resolution of 20 millivolts. There are several methods that could be used to implement such a system, one could use 16 separate analogue to digital converters working in parallel. Although such a system could be used to provide fast parallel conversion, it would be expensive and require an excessively large circuit board.

An alternative solution is to have one analogue to digital converter and have a switching system to determine which of the 16 inputs is to be converted. It would be possible to use an ordinary rotary switch or 16 relays to provide the switching. The rotary switch would not allow automatic switching and the relay method would be bulky, require drivers and increase power supply requirements. An alternative, and more elegant, solution is to use semiconductor switches which consume little power, occupy small volume and are readily available.

As is often the case, if there is a sufficiently large requirement for a particular device, one manufacturer or another will produce it. In this case National Semiconductor comes to the rescue with its ADC0817. Not only does it use the successive approximation conversion technique described above, but also includes a 16 channel analogue switch within a 40 pin package.

ADC0817

The pinout of the ADC0817 is shown in Fig. 2 and its block diagram in Fig. 3. It can be seen that even though this is a fairly complex device, it can be divided into a number of easily understood sectors.

The sixteen analogue inputs are connected to the 16-channel analogue multiplexer. The input selected is determined by the output of the multiplexer address latch and decode

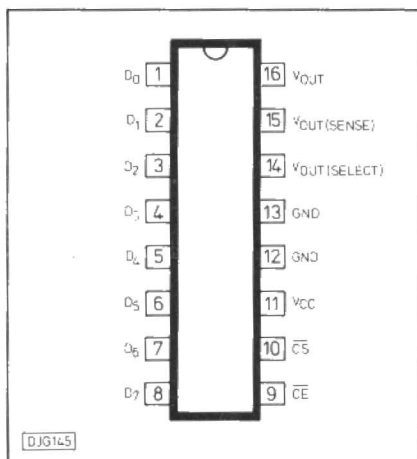


Fig. 4. AD 558 pin-out

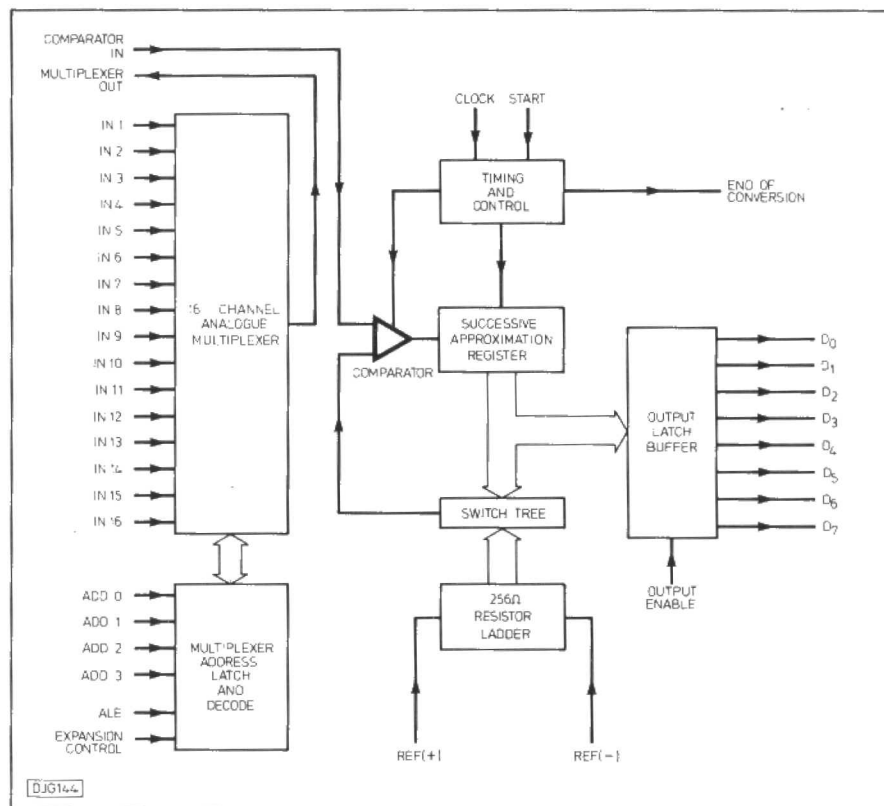


Fig. 3. Block diagram of ADC 0817

circuitry. The required channel number is written into this section, via ADD0 to ADD3, by the host system before the analogue to digital conversion process is started. Data is allowed into the latch only when the ALE input is high, and stored when ALE is low. The system allows more than 16 channels to be implemented by means of the expansion control input. This is used to switch off the analogue multiplexer so that other multiplexers can be included in a system. However, for the purpose of this project it is assumed that 16 channels will be adequate for most applications.

Now that an analogue channel has been selected, the signal can be passed to the analogue to digital converter section of the device. The multiplexer output and comparator input use separate pins so that the conditioning circuit can be inserted between the two sections should it be necessary.

The successive approximation conversion technique has been described above, and it will be noted that the various parts required are all present within the ADC0817. The 256R resistor ladder is configured such that its two ends are unconnected and made available to the user. These are labelled REF(+) and REF(-). This allows the conversion range to be determined by the user to suit a particular application. For example, if the REF(-) is connected to say, 1V and REF(+) to 2V, then the conversion range would be 1 to 2 volts.

Control of the conversion technique is undertaken by the successive approximation register. This determines which switches within the switch tree are selected by referring to the comparator's output. This system will only carry out a conversion when required. The START input is used to inform the ADC0817 that a conversion is required. When a conversion has been completed the ADC0817 generates an end of conversion signal. The host system could

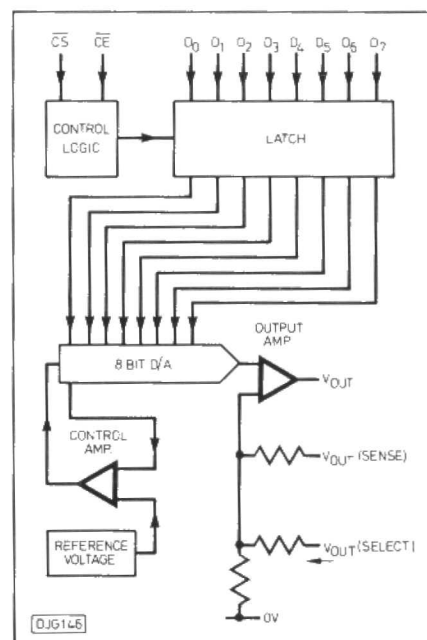


Fig. 5. AD 558 Block diagram

use this as an interrupt or it could poll as required.

The result of the conversion is stored as an 8-bit data word in the output latch buffer with tri-state outputs. These are controlled by the OUTPUT ENABLE input. This arrangement allows the device to be connected directly to the data bus of a host computer or microprocessor as a memory mapped device.

DIGITAL TO ANALOGUE CONVERTER

Having discussed the analogue to digital converter, now let us consider the digital to analogue converter. The device chosen for this project is the Analogue Devices AD558. The pin connections for this are shown in Fig. 4 and the block diagram in Fig. 5.

Data representing the required output voltage is applied to the device's latch inputs, D0 to D7, from the host system's data bus. However, this can only be achieved when both the CE and CS inputs are low. The actual conversion technique employed by this device is the R-2R method. This was described in the MAY 1986 BBC Microforum. In the case of the AD558 the reference voltage is generated by an internal band gap reference. An output amplifier is also contained within the AD558 together with three resistors. By utilising these resistors in various ways, and by providing suitable power supplies, the device can be made to cover various voltage ranges.

PE HOBBY BUS D/A & A/D BOARD

The two devices described above are used in the design of the PE Hobby Bus D/A and A/D board. One ADC0817 and two AD558s are used to provide 16 analogue inputs and 2 analogue outputs. The ADC0817 is configured to cover the range 0-5 volts while the AD558s cover the range 0-2.55 volts. The full circuit diagram is shown in Fig. 6. It will be noted that in addition to the main devices, only two additional chips are required.

A 74LS138 is used to generate the five on board select lines required to control the board's operation. It uses only two

Table 1. Select line functions

Address	read or write	function
00	write	latch ADC0817 analogue multiplexer address
01	write	start ADC0817 conversion
02	write	load AD558 No.1
03	write	load AD558 No.2
00	read	read ADC0817 output

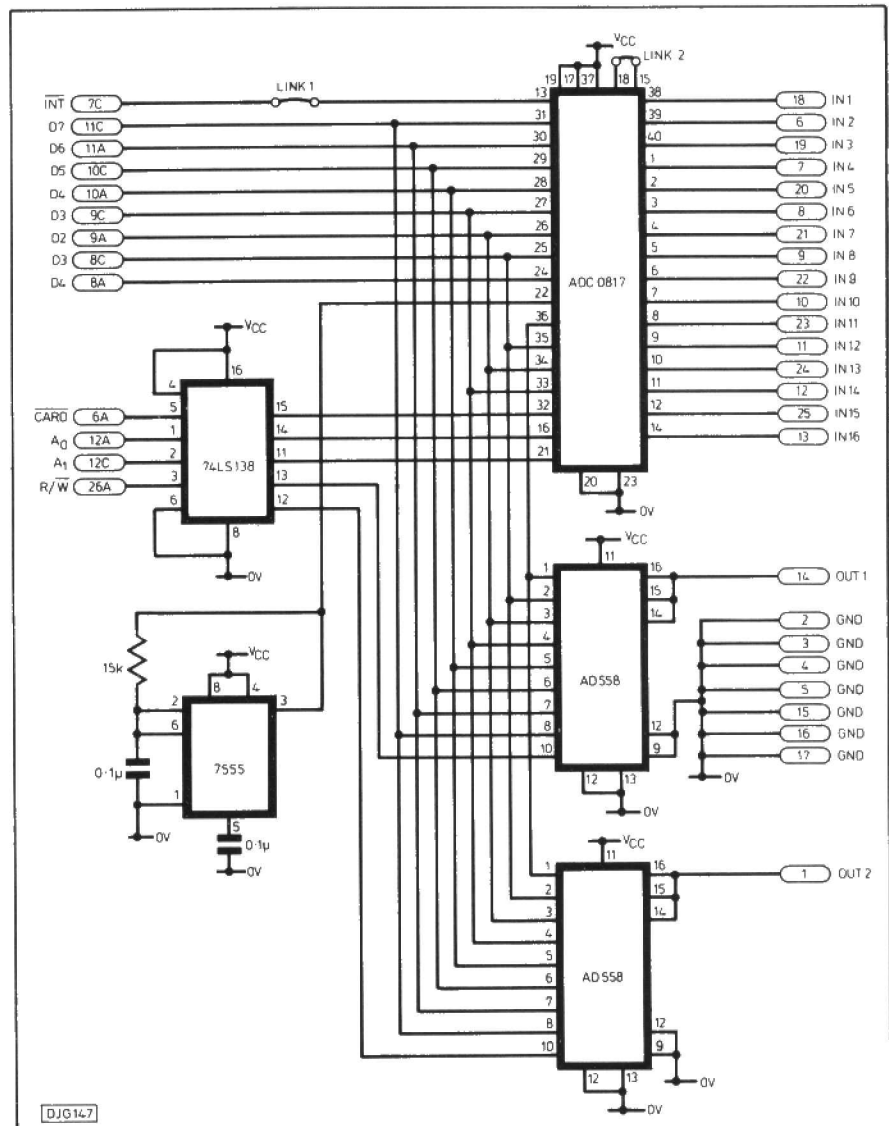


Fig. 6. Complete circuit diagram

of the Hobby Bus address lines, A₀ and A₁, the R/W line and the board select line. Four of these on board select lines are *write* only, whilst the fifth is *read* only. To achieve five select lines while only utilising two address lines, the address lines are gated together with the R/W line by the 74LS138. In fact two select lines, one read and one write, occupy the same address. The actual functions for these select lines are detailed in Table 1. The board select line is used to enable the board when the appropriate bus slot is selected.

In this design the ADC0817 is configured to convert input voltages in the range 0 to 5 volts. To achieve this REF(+) is connected to Vcc and REF(°) to Gnd, and the output of the analogue multiplexer is connected directly to the comparator's input. The lower four data bus lines are used to indicate to the analogue multiplexer the required input, and in conjunction with the upper four address lines, transferring data to and from the host computer or microprocessor.

The ADC0817 requires a clock input of about 500KHz to allow it to function. As the circuitry is designed to operate in conjunction with a range of single board microprocessor and home microcomputers it cannot be assumed that a clock of this frequency will be available. A 555 is therefore included on the board so that operation is not dependent on the host system. It will be noted that the normal 555 multivibrator circuit, which uses two timing resistors, has been replaced by this circuit which uses only one. This has the advantage of providing an output waveform with equal mark-space ratio as well as only using one resistor.

BOARD CONSTRUCTION

The circuit has been designed on a standard Hobby Bus Eurocard sized (100 x 160 mm) printed circuit board. The component layout is shown in Fig 7. It can be seen that the printed circuit board is single sided thus making the cost of the board cheaper than a double sided version. In addition, provision is made

HOBBYBUS A/D & D/A BOARD

to allow the ADC0817's *end of conversion* signal to be connected to the bus's interrupt line if required. Connection to the Hobby bus is achieved by means of a 64 way DIN 41612 connector using pins A and C. The analogue inputs and outputs are connected by means of a 25 way D-series connector at the opposite end of the board. The functions of this connector are detailed in Table 2.

Construction is straightforward and should present no problems to most constructors. However, care should be taken to ensure that the chips are inserted the correct way round, and it is recommended that IC sockets are used. Link L1 should be inserted if the *end of conversion* signal is to be used as a system interrupt.

SOFTWARE

The Hobby bus is designed so that it is compatible with a range of home computers and single board microprocessors. Thus, as all these could have different operation systems and interface memory maps, it is not possible to give detailed software listings. However, it is possible to present software flow charts that can be used as the basis of a programme for any system. These are shown in Fig. 8, one for the analogue to digital converter and the other for the digital to analogue converter.

First let us consider the analogue to digital converter flowchart shown in Fig 8A. The first operation that has to be undertaken is to select the analogue channel to be measured. Let us assume that the channel required is number 8. If the controlling device is a home computer the channel can be selected by the following statement:

POKE &XX00,&08

Table 2. 25-way D-type connector functions

Pin	Function
1	OUTPUT2
2	GND
3	GND
4	GND
5	GND
6	INPUT2
7	INPUT4
8	INPUT6
9	INPUT8
10	INPUT10
11	INPUT12
12	INPUT14
13	INPUT16
14	GND
15	GND
16	GND
17	GND
18	INPUT1
19	INPUT3
20	INPUT5
21	INPUT7
22	INPUT9
23	INPUT11
24	INPUT13
25	INPUT15

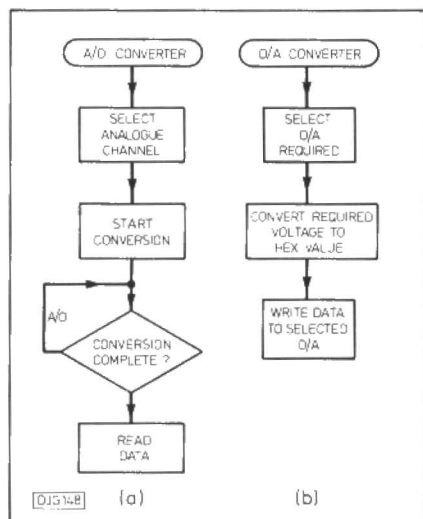


Fig. 8. Software flow chart

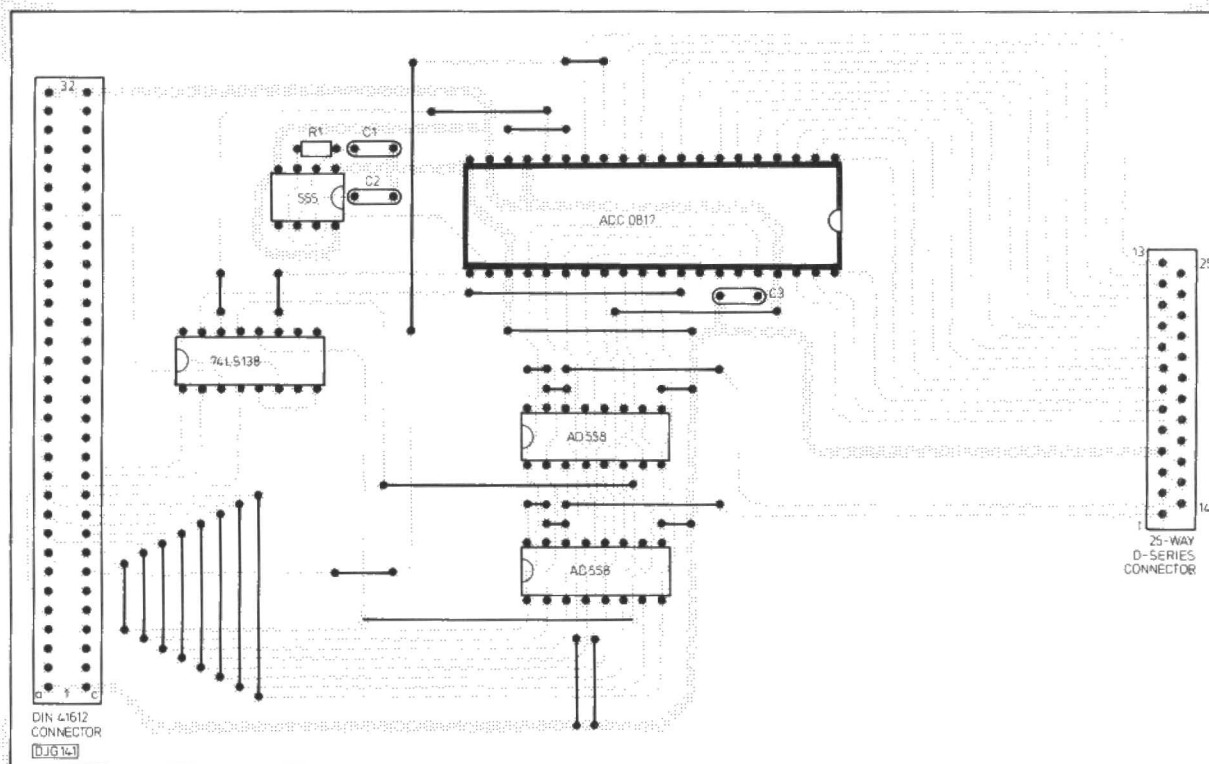


Fig. 7. P.c.b. layout and component position details

The value of XX will depend on the interface address of the computer used, and will be found by reference to that computer's user manual.

Once the required analogue input has been selected, the conversion process can be started by POKE &XX01,&00. The actual value POKEd is not important as it is not used by the system, &00 is used for convenience only. There are two methods by which end of conversion can be detected, depending on the user's requirements. The most efficient method is to use the *end of conversion* signal to interrupt the host system. However, if for whatever reason this is not possible, all that one need do is to introduce a delay long enough to allow conversion to be completed. When end of conversion is detected by whichever method is used, the data can be read using the statement PEEK &XX00. As the data range of &00 to &FF represents a voltage range of 0 volts to 5 volts the actual voltage is easily determined by using $VOLTS = DATA * 5/128$.

Setting the output voltages of the two digital to analogue converters is even simpler. All that is necessary is to convert the required voltage, which will be within the range 0 to 2.55 volts to its digital representation, i.e. &00 represents 0 volts and &FF represents

2.55 volts. Once this data has been established it is written into the appropriate AD558 as follows.

For AD558 number 1 : POKE &XX02,DATA or

for AD558 number 2 : POKE &XX03,DATA

TYPICAL APPLICATION

Now that the circuit has been described let us consider a typical application. One of the most common measurements made is that of temperature for which there is a wide range of transducers available. There is, however, one type of transducer that is particularly relevant, the AD590 semiconductor temperature transducer.

The AD590 is an integrated temperature transducer which produces an output current proportional to absolute temperature. This current is set during manufacture to 1 microamp per deg K. All that is required to produce a signal acceptable to the ADC0817 is two resistors in series with the AD590 as shown in Fig. 9. The variable resistor allows the system to be calibrated. Crushed ice can be used to set 0 deg C and boiling water to set 100 deg C. The actual voltage generated by the AD590 is determined by using the following formula.

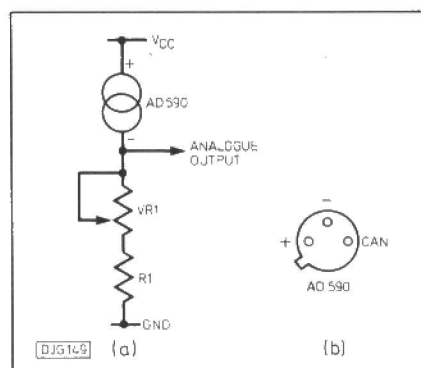


Fig. 9. Temperature circuit

$$\text{Voltage} = R \times \text{Deg K} \times 10^{-6}$$

Where R = Total resistance.

Remember that 0 deg C = -273 deg K. Thus the AD590 generates 0 volts at -273 deg C, $R \times 273 \times 10^{-6}$ volts at 0 deg C and $R \times 373 \times 10^{-6}$ volts at 100 deg C. The use of an AD590 simply illustrates just one of many parameters that can be measured by using suitable transducers.

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THE LEADING EDGE

BY BARRY FOX

Crime-busters and grid references

THERE is some interesting technology and politics behind British Telecom's plan to curb crime by putting 1500 UHF radio beacons on top of lamp posts in the London area by the end of the year. The BT crimebuster is called Pinpoint and it is intended primarily to let high risk vehicles, like mail vans and security trucks, tell a control centre where they are at all times. Pinpoint could one day be used in private cars to help their drivers navigate unfamiliar routes. It builds on a system unveiled earlier this year by Plessey. Although everyone is being very tactful about what they say, it is clear that BT has solved technical problems which made the Plessey system unreliable in city centres.

The backbone of Pinpoint is the network of BT radio beacons. They will continually transmit grid reference signals, and so give passing vehicles with matching receivers a fix on their location. The vehicles will then transmit an identifying signal back to a base station which logs and displays their exact position on a city map. This, claims BT, will let security firms and the Post Office postal vans keep a continuous check on their fleet of mobiles and alert the police if there is a robbery, hi-jack or deviation from the pre-planned route.

In January when Plessey was embroiled in a takeover bid by GEC, the company generated a welter of well-timed publicity for PACE (Plessey Adaptive Compass Equipment), a car navigation system. It relied on a compass, motion sensor and computer which matched the car's estimated position with a map stored in a digital memory. When Plessey demonstrated Pace, the cost was put at only £500. The compass must recalibrate itself to compensate for stray magnetic fields. Pace worked well on country lanes, which is where Plessey demonstrated the system mainly to non-technical motoring journalists. They missed the significance of the rural demo, far from magnetic distractions, and duly wrote about how wonderfully Pace worked. When quizzed Plessey later admitted to me that the system did not work properly in city traffic and had "problems" on city roads. The compass was disturbed so that the computer had trouble matching the car's position with its map. Philips had experienced exactly

the same problem with CARIN (Car Information and Navigation) which stores the maps as digital code on compact disc. Philips plans to use location signals from satellites to keep Carin on track. The Plessey compass must be regularly recalibrated.

Enter BT, who will solve the compass problem by the sledgehammer technique of erecting UHF radio beacons every 2 km. These will transmit their own grid reference positions to any Pinpoint receiver passing within 100 metres. The system continually tells the compasses where they are. When the system was announced in the spring BT had erected only 30 beacons and was testing the system with 2 security vans. But BT says it hopes to install the rest by the end of the year.

Accuracy of 50 metres is claimed, with a position update every few seconds. But on the demonstration system markers on screen moved in jumps of up to 1 kilometre road distance. This, says BT, is because the system displays the last positively known position to foil robbers who rip out the vehicle aerial. The position signal from the demonstration vehicle is digital and it was lost or corrupted as the vehicle drove under Holborn viaduct. The dot on the screen

money. So Pinpoint is a chicken and egg technology. The cost of saturating the UK's 0.25 million square kilometres with grid reference radio signals will surely be prohibitive, even on BT's current level of profits!

Encryption of the radio signals is only one of several defences which Pinpoint uses against hi-tech bandits; it prevents them commandeering a beacon and putting out false position signals to fool the control centre. The beacons are all battery-powered to safeguard the service against mains failure. BT acknowledges that it would be easy to identify the transmission frequency used by the beacons, and transmit a jamming signal, but thinks it can cope by identifying the location of the jammer. Likewise BT thinks it can cope with the havoc in the onboard compass which would be caused if a hijacker with a large lump of metal or magnet parked alongside the security vehicle. Time will tell. Significantly Plessey has gone very quiet on Pace. Anyone who believed those press reports early this year about low cost navigation for private cars is in for a long and probably disappointing wait.

Pinpoint is not cheap. The transceiver in each vehicle will cost £1000 and each central control station, with a Digital PDP-11 mini-computer, will cost up to £1m depending on the complexity and

number of vehicles to be controlled. Erecting 1500 beacons to cover the M25 ring will cost £1m. Because BT cannot claim a patent monopoly on the system it is unable to prevent other firms selling similar hardware to work with the BT beacons. So BT will charge a subscription of around £100 a year per vehicle using the beacons. "Pirate" vehicles, with non-BT hardware, will not be able to take advantage of the beacons because their signals are encrypted. It's all a very far cry from Plessey's £500. Extending the system outside London will be even more expensive, despite the fact that beacon spacing can spread to 15 km.

The Pinpoint system shown to the press by BT was still clearly a prototype. On one occasion the vehicle being tracked appeared to have jumped over a built-up area.

Plans to curb crime using 1500 UHF radio beacons on London lamp-posts giving an accuracy of 50 metres and position update every few seconds – for security and mail vans.

map cannot move until reliable signals come through again.

Commercial success or failure depends on BT's ability to prevent hardened criminals from trying to defeat Pinpoint by jamming the beacons and confusing the compass with hit and run electronics. BT is confident that Pinpoint will keep on working and give the police an alarm and fix which is accurate to 50 metres within 15 seconds.

BT hopes the police, VIP escorts, courier services, taxis and eventually the general public will use Pinpoint. BT claims success with its trials with two security vans and 30 beacons, but will not identify the customer who it says is satisfied. Also although BT promises to cover the whole of the UK with beacons, and so protect vehicles outside the London area, this promise can only be honoured if the London service makes

ELECTRONIC EXPERIMENTATION

BY THE PROF.

When the hobby of electronics is mentioned probably most people think in terms of building electronic gadgets, but there are more facets to the hobby than just soldering components onto a printed circuit board. One aspect which has been largely overlooked in recent years is that of experimenting with the more unusual types of project, seeing just what they can and can't do, and freely adapting and changing them in an attempt to improve their performance or to customise them to the constructor's individual requirements.

The purpose of this new series is to provide circuits and ideas of interest to those who like to experiment with electronic devices. By the nature of things the topics covered will be diverse and difficult to categorize, but the main factor they will have in common is that they will be interesting and have good 'play value', with practical application being of only secondary importance. Another factor is that the circuits described will not require large double-sided printed circuit boards, and they will be the type of thing that can easily be breadboarded or put together on a piece of stripboard. Printed circuit boards are ideal for permitting finalised designs to be easily copied by others, but they are restrictive as far as experimentation is concerned, and no printed circuit designs will be provided for the circuits. On the other hand, the designs that are described will all have been tried and tested, and will represent a sound starting point but not necessarily the final word.

INFRA-RED AUDIO

Although radio links are the only common form of 'wireless' communications, there are in fact a number of alternatives available. One of the better known of these is the so-called modulated light telephone, and this consists basically of a torch at the transmitter with the brightness of the bulb modulated by the audio input signal. The receiver consists of a photocell circuit driving an audio amplifier. This gives far from hi-fi results, but it is adequate for voice communications, and a range of 20 to 40 metres can usually be achieved without too much difficulty.

This design is a more up to date version of a modulated light beam communicator, and it differs from the standard approach principally in that it uses infra-

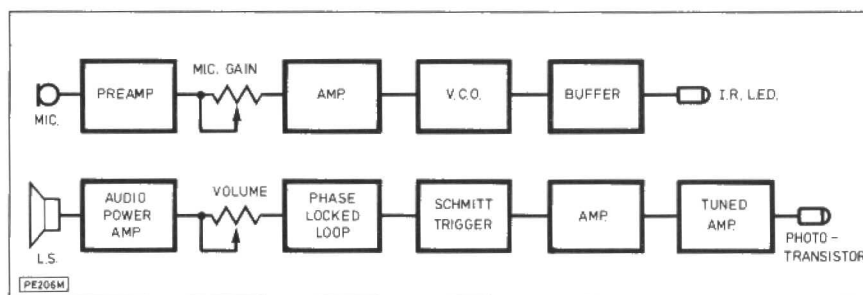
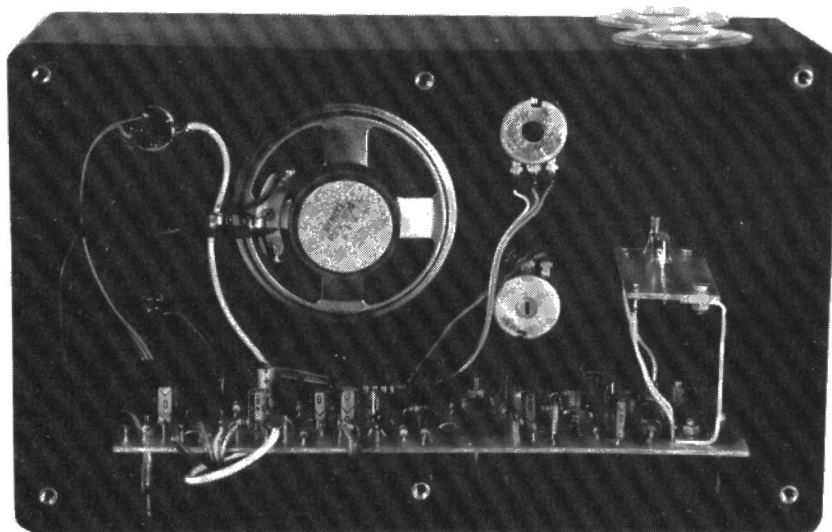


Fig. 1. IR Communicator block diagram

red light. There is no significant output from the transmitter in the visible light part of the spectrum, and consequently there is no obvious link between the transmitter and the receiver. It has to be admitted that communications via an infra-red link is not a particularly new idea, and systems for military use have been in existence for at least twenty years, but there has been little coverage of this subject in electronics publications. For the military the lack of any connecting wires, no obvious signs of a communications link, and its tap-proof nature have obvious

attractions, and the same properties give such a system considerable appeal for private users as well.

The system described here achieves a range of at least 40 metres using an inexpensive optical system. The range of any communications system using light transmission is as dependent on the optics as it is on the electronics, in much the same way that the range of a radio link is largely dependent on the aerials used. Alignment of the optics is quite critical and the equipment needs to be carefully set up and maintained in alignment. This is a rather inconvenient



aspect of infra-red communications, but it is this directivity that enables a useful range to be obtained as well as ensuring privacy.

SYSTEM OPERATION

Ordinary modulated light telephone systems are limited to simple AM operation due to the low maximum switching speed of a torch bulb. With an infra-red system using an l.e.d. as the transmitting element, frequencies of 50kHz or more can be accommodated, making a simple FM system feasible. An FM system has the advantages of rendering non-linearity in the photocells unimportant, and greatly reducing problems with noise from mains lighting or other infra-red sources.

Fig. 1 shows the block diagram for one transceiver unit. Starting with the transmitter, which is the less involved of the two sections, the signal from the microphone is at a very low level of no more than about 1 millivolt RMS. It is therefore amplified by a two stage amplifier before being applied to the modulator. A microphone gain control enables the modulation level to be adjusted. The microphone is a low impedance (200 or 600 ohm) dynamic type, and a press-to-talk dynamic type is ideal. It would be quite possible to switch the loudspeaker at the receiver to operate as a sort of crude microphone,

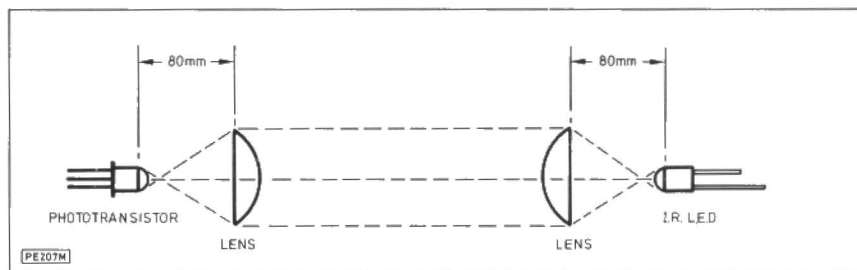


Fig. 2 Simple optical system

sufficient drive for the infra-red l.e.d. which is consequently driven by a buffer stage that has a very low output impedance.

Turning to the receiver section, the infra-red detector is an ordinary phototransistor. Although phototransistors tend to be thought of as only suitable for visible light applications, in common with many other types of opto device they mostly have a peak response in the infra-red part of the light spectrum.

As the output from the detector circuit is likely to be extremely small, being in the microvolt range rather than a matter of millivolts, a great deal of amplification is needed ahead of the demodulator. This is provided by a tuned amplifier followed by a two stage broadband amplifier. The tuned amplifier does not have a very sharp response, but it gives sufficient attenuation at low frequencies

to largely eliminate problems with mains loop type. This consists of a phase detector, a lowpass filter, and a VCO. The circuit is arranged so that the phase detector (via the lowpass filter) provides a control voltage to the VCO, and this voltage is dependent on the phase and frequency difference between the input signal and the output of the VCO. The result of this is that the VCO is locked onto the same frequency as the input signal, and in-phase with it. In this case it is not the output signal of the VCO that is of interest, but the control voltage. This rises and falls in sympathy with the variations in input frequency, converting these changes back to the original audio signal.

The demodulated audio signal is fed via a volume control to an audio output stage which in turn drives the loudspeaker.

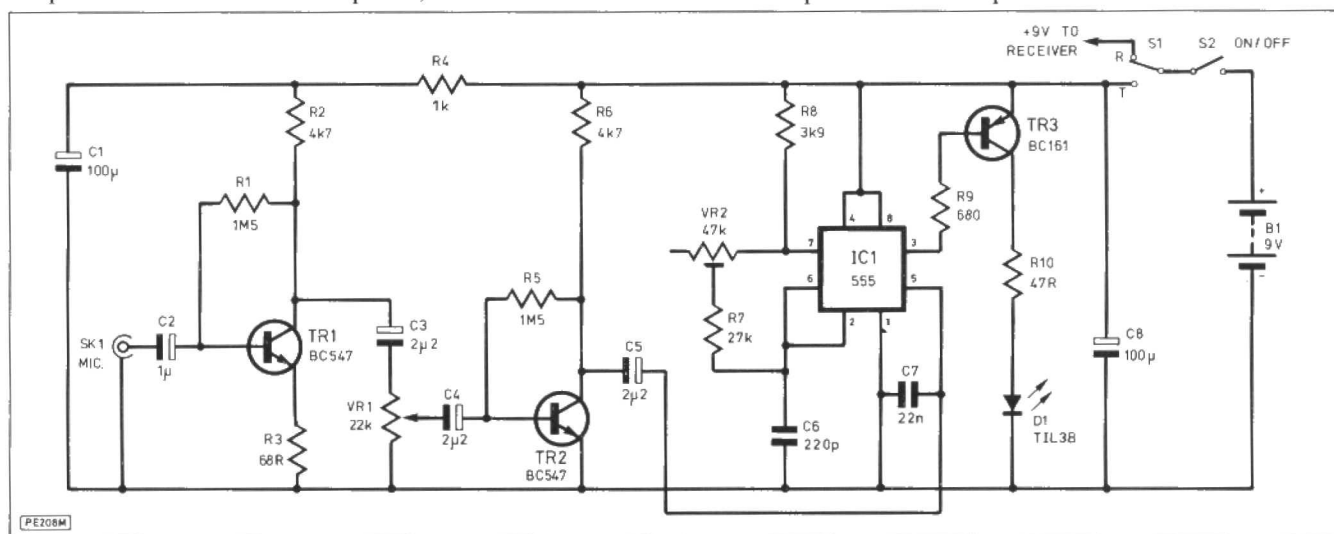


Fig. 3 Transmitter circuit diagram

as in many intercom designs, but this would give extremely poor audio quality and the use of a proper microphone is infinitely preferable.

The modulator is just a voltage controlled oscillator (VCO) with the audio signal coupled to the control input. The output frequency of the particular VCO used here, unlike most types, rises as the control voltage decreases, and falls as it increases. This is of no practical importance though, and it simply results in an inversion of the signal through the system, which gives no audible change. The VCO has insuf-

lighting and other infra-red noise sources. The attenuation at high frequencies helps to avoid problems with instability.

The amplifier is followed by a Schmitt Trigger which gives a squarewave output to drive the demodulator. With only background noise from the amplifier there will normally be insufficient signal to drive the trigger circuit, which consequently provides no output signal. This gives a sort of crude squelch system, with a low noise level from the circuit under no-signal conditions.

The demodulator is a phase locked

OPTICS

Most opto devices have simple built-in lenses, but for operation over fairly long ranges these are totally inadequate. On the other hand, a quite fundamental optical system of the type shown in Fig. 2 is all that is required. The light output from the LED is focussed into a narrow beam by a plano-convex lens. Things are somewhat idealised in Figure 1, and in practice the beam will spread out somewhat and will not be perfectly focussed. This reduces the range of the system, but makes optical alignment

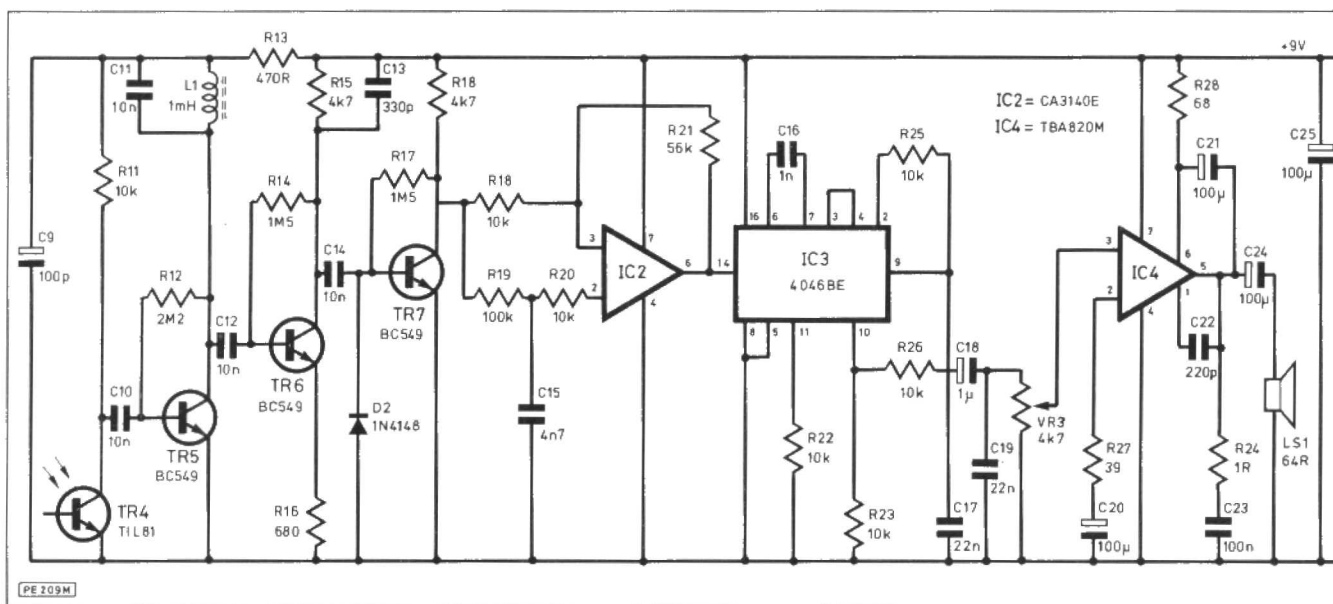


Fig. 4. Receiver circuit diagram

very much easier. A second plano convex lens, at the receiver this time, collects up the infra-red radiation from the transmitter over a comparatively large area, and concentrates the collected energy onto the phototransistor. The distance between each photo device and its lens should be roughly equal to the focal length of the lens which is approximately 80 millimetres in this case. The optical quality of the lenses is of little importance, and inexpensive plastic types are perfectly satisfactory.

TRANSMITTER CIRCUIT

Fig. 3 shows the full circuit diagram of the transmitter. TR1 acts as the microphone preamplifier, and it operates as a common emitter amplifier. The output from TR1 is coupled to a second common emitter stage (TR2) by way of gain control VR1. The VCO is based on a 555 timer device (IC1) which offers quite good performance at low cost. The circuit is a standard 555 astable type, with the centre frequency adjustable by means of VR2. This is adjusted to tune the transmitter to the centre of the receiver's passband.

Normally the circuit oscillates by continuously charging timing capacitor C6 to two thirds of the supply voltage and then discharging it to one third of the supply potential. The upper threshold voltage can be varied by an external voltage applied to pin 5, and raising the threshold voltage results in C6 taking longer to charge and discharge, giving a reduction in operating frequency. Reducing the threshold voltage has the opposite effect. Therefore, by simply coupling the audio signal to pin 5 of IC1 the required frequency modulation is produced. Frequencies above about 3kHz are not needed for voice communications, and C7 is used to provide roll-off above this

frequency. This gives a slightly improved signal to noise ratio and avoids problems with high frequencies causing overmodulation.

IC1 has a fairly high drive current capability, but the LED current can be set more reliably if an output amplifier is used. In this case the amplifier is TR3 which operates as a common emitter switching transistor. R10 sets the l.e.d. current at over 100 milliamps, but the average l.e.d. current is only about 60 milliamps. The current consumption of the circuit as a whole is somewhat higher at around 80 milliamps. This is low enough to permit battery operation, but a fairly high capacity 9 volt type (such as six HP7 cells in a holder) is needed, and the use of Nicad rechargeable cells is preferable.

S1 is the transmit/receive switch, and it merely switches the supply to the transmitter or receiver circuit, as required. If a PTT microphone is used S1 can be the PTT switch. Otherwise S1 can be a separate SPDT miniature toggle type.

RECEIVER CIRCUIT

The receiver is slightly more complex than the transmitter, as can be seen from the circuit diagram of Fig. 4.

TR4 is the phototransistor, and here its collector to emitter leakage provides a sort of light dependent resistor action. Note that no connection is made to the base terminal of TR4.

The tuned amplifier has TR5 as a common emitter amplifier with L1 and C11 acting as the tuned circuit load. The resonant frequency is fixed and is approximately 50kHz. The output from TR5 is coupled to a second common emitter amplifier which is based on TR6. This has its input impedance boosted somewhat by emitter resistor R16 so that it does not load the tuned circuit very

heavily. The tuned circuit still has a fairly broad response though, which is essential as the carrier deviation can be quite large. TR7 is a third common emitter amplifier, and D2 prevents this from being overloaded when a strong signal is received.

IC2 acts as the Schmitt Trigger. Both its inputs are biased to the output potential of TR7, but a decoupling network (R19 - C15) is included in the path to the inverting input. This results in the high frequency output signal of TR7 being coupled to the non-inverting input but not to the inverting input. The output of IC2 produces a clipped version of the input signal, and R21 introduces hysteresis which gives the circuit a simple squelch action.

The phase locked loop demodulator is built around IC3 which is a CMOS 4046BE type. This has C16 and R22 as the timing components in the VCO, and R25 plus C17 as the lowpass filter. The demodulated audio signal is taken from the lowpass filter via an integral source follower buffer stage which has R23 as its discrete load resistor. R26 and C19 form a simple lowpass filter which helps to give an improved signal to noise ratio, and VR3 is the volume control. From here the signal is coupled to a simple audio power amplifier based on IC4 which is a TBA820M. This gives an output power of only about 100mWRMS into LS1, but this is perfectly adequate for the present application.

CONSTRUCTION

There is no real difficulty with construction from the electrical point of view, but bear in mind that the receiver circuit includes a high gain amplifier, and reasonable precautions to avoid stray feedback and consequent instability should be taken when designing the component layout.

this. One possible way of improving range is to feed the transmitting I.e.d. with short pulses rather than a more or less squarewave signal. This enables a very high I.e.d. current to be used, but with a mark-space ratio of around 1 to 10 the average I.e.d. current can still be kept within the limitations of the TIL38. This method does have attendant problems though, one of which is the reduction in output at the fundamental frequency and increased output at harmonics. In order to take advantage of the power in the short pulses the amplifier at the receiver must have an adequate bandwidth, and must therefore be a broadband type rather than tuned. Some pulse shaping might also be needed ahead of the phase locked loop in order to obtain good results, or an alternative type such as a monostable might work better.

There is probably most scope for experimentation with the optics. One obvious addition would be an infra-red filter ahead of the phototransistor. This would eliminate any noise caused by visible light sources, and could give greatly improved performance under marginal operating conditions. The transmitter could be given increased output by using a longer focal length lens of greater diameter. Similarly, the receiver could be made more sensitive



by using a larger lens. A larger lens at the receiver might produce an image size larger than the phototransistor, and better results might then be obtained using a TIL100 or similar large area (infra-red) photodiode. The lenses do not need to be high quality types, and both double and plano convex types are suitable. Lenses from large magnifying glasses have suitable characteristics and are not excessively expensive. With the

right optical system a range of a few hundred metres should be possible.

What would probably represent the most useful addition of all would be some form of simple sight on each unit to permit quick and easy realignment of the system. A sight would be especially useful if an improved optical system is devised, as the more efficient the optics are made, the more directional the system becomes.

PE

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ROBOTICS REVIEW

BY NIGEL CLARKE

Robot Heroes remote in the USA

ABOUT three years ago when the concept of personal robots began to seep over the Atlantic from the US and people first realised that robots did not have to be large industrial machines which helped to make cars, there was one product which stood out from the rest.

Like the others which were first on the market, the RB5X and Androbot's Topo, it was American and met people's expectations of what a small mobile robot should look like – usually something similar to Star Wars' R2D2. Unlike the others, however, it withstood closer inspection and managed to avoid the criticism that it was merely a rich person's toy.

The main reason was that Hero 1 from Heathkit did not attempt to create a market but was supplied in response to demand from education for a machine which could help in learning about robotics. It was therefore much more complex and although more expensive it sold well and has continued to do so.

Since it was launched in Britain by Maplin Electronic Supplies of Essex, small improvements have been made but there has been no new product launch partly because there has been no competition. It did attempt to expand the market by introducing its own personal robot, marketed in the States as a mechanical friend and watchdog with embarrassing pictures of it enjoying a drink in a bar, but it only served to confirm the experience of Topo and RB5X. It failed to gain any general appeal and sales have been slow.

There is now, however, an upgraded version called Hero 2000. It has been available in the States for some time but that version could be radio-controlled using a frequency which is illegal in Britain. The feature has been removed and Maplin is importing the machine.

It has also the capabilities of the earlier Hero with movement, an arm, speech and the ability to detect light, sound and motion. It comes in a kit and forms part of an educational course.

It is much more powerful though. It has a 16 bit 8088 central processor with 64K ROM and 24K RAM, expandable to 576K and a disk drive option, against a 6808 processor with 8K ROM and 4K RAM. Hero 2000's central processor interfaces with 11 8K processors which control the functions.

The new robot is driven around by a two wheel drive system, an improve-

This is the last in our regular series of Robotics Reviews as we know them. The subject of Robotics will, however, be covered in our news pages and special features in the future.

ment on the single wheel system of Hero 1, and the arm is now a much more important part of the machine. The Hero 1 arm had four degrees of freedom, one of which was provided by the swivelling head to which the arm was attached, the others being a shoulder and wrist pivot and rotate, plus a simple gripper. The main limb could be extended. The 2000 is more similar to the traditional articulated arm with five degrees of freedom being shoulder, elbow, wrist pivot and rotate and the swivelling body of the robot to which the arm is attached. The gripper has a touch sensor which can adjust the gripping force. It can lift 1lb which is much the same as the older machine when the arm was not extended. At full extension the maximum load was cut by half.

The movements for 2000 are driven by eight closed loop servos compared with steppers for the older machine.

The speech system has also been expanded from its 28 in-built phrases and the possibility of inputting about 750 words to what the makers claim is an almost unlimited vocabulary with direct text-to-speech conversion for easier programming. The synthesiser also can produce four octaves of music and sound effects.

In addition the 2000 has 2 RS232 ports, configured for terminal and printer, a cassette port to allow storing and loading of programs and the option of adding 12 circuit cards to expand its capabilities. The ROM contains a number of items including special robot commands and demonstration and diagnostic routines. The robot also has 16 functions, eight of which are user-definable.

The cost for all this is about £2,200 plus VAT for the kit. Maplin intends selling a ready-built version but has yet to set the price. Hero 1 now sells for about £1,200 in kit and £2,200 ready-built, both with VAT extra.

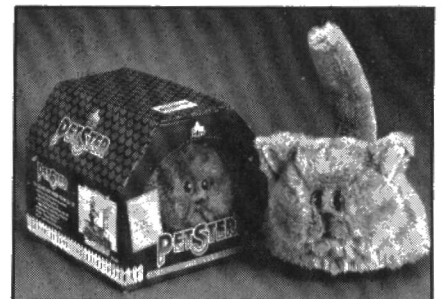
As with Hero 1 the 2000 is aimed at the education market and there are two specially-written courses to complete the package. For almost £100 each they are entitled Intelligent Machines and

Electronics for Automation. The makers also say it will be of interest to the home enthusiasts who have worked their way through hi-fi and computing and are looking for a new challenge.

If you are worried that the image of robots is not cuddly enough, Axlon of the States has the answer – Petsters. The electronic furry toys last year gave the company a successful first year with rapid growth and they are now available over here.

To quote the company's blurb: "Petster was the world's first electronic pet. It has high quality plush fur, eyes that light up and a microprocessor mind of its own."

Petster looks like a toy cat and is said to obey spoken orders to move forward and back, turn right or left or just make a sound. Petster deluxe, a bigger cat,



has 69 programs, with bump and sound sensors. In the same range there is Petster Puppy which moves in response to handclaps.

The cuddly mechanicals are being distributed here by Tomy which is already well known for its own range of toy robots and Petsters are only one group of furry electronic toys from Axlon which the company is bringing to our shops – A.G. Bear, with grandparents and a baby, is a range of teddy bears which can respond in their own language when spoken to. The reply is a distorted version of what has been said to it achieved by converting the original analogue speech into digital signals and then back to analogue.

There is also a set of glove puppets which speak when their mouths are opened, a light sensor activating the speech chip.

PE

SHOESTRING CAD/CAM

BY R. A. PENFOLD

You have a computer – use it!

Over 80% of PE readers own personal computers. If you have not got round to making add-ons and peripherals but are interested in electronics, you now have a chance to use your computer for a practical purpose (not Space Invaders). Cheap electronic software packages are available for drawing, designing and p.c.b. mask manufacture.

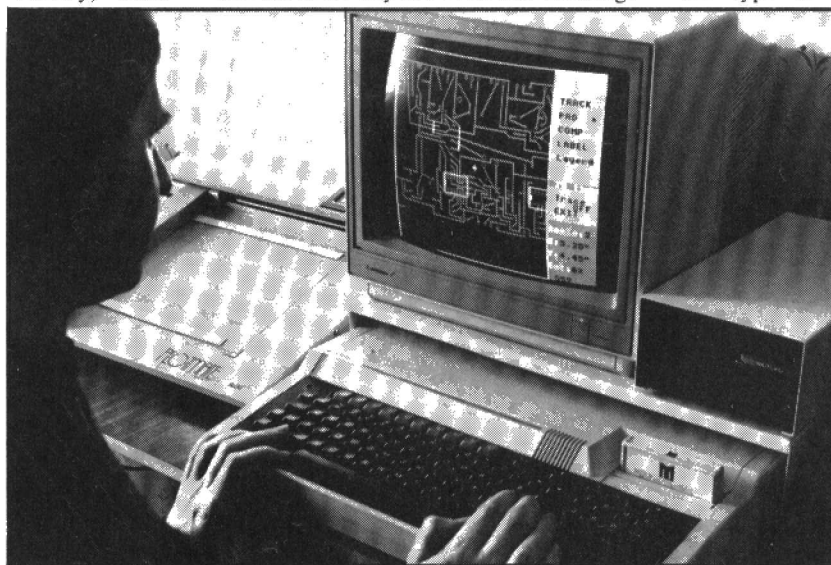
A FEW years ago an article on CAD/CAM for home microcomputer owners would have had to be extremely short, since there was little or no software for CAD/CAM applications that would run on any home computer. In fact until fairly recently systems of this type were only based on mainframe or (more usually) mini computers.

Microcomputers have gradually become more sophisticated and a lot of ingenuity has been put into stretching their capabilities. As a result of this there is an increasing amount of CAD/CAM software becoming available for use with microcomputers, including a certain amount for the more popular up-market home computers such as the BBC and Amstrad machines. It is still quite expensive to set up a simple CAD/CAM system even if you already have suitable hardware since most of the programs are well beyond games software prices. This makes CAD/CAM a more attractive proposition to small scale commercial users and educational establishments than to electronics hobbyists, but if prices continue to fall it could be that before too long simple CAD/CAM setups will become really affordable.

In this article we will take a look at inexpensive CAD/CAM in general, and some representative programs in particular. CAD and CAM are perhaps not familiar terms to everyone involved

in computing, but CAD stands for 'computer aided design', or it is sometimes used to mean 'computer aided drawing'. In fact CAD is largely to do with drawing, since much design work involves the production of detailed diagrams and drawings. However, some CAD systems are only to do with design and are in no way involved with drawing.

produces circuit diagrams would not really come under the heading of CAM equipment, but one which aids the production of printed circuit boards and generates accurate drawings from which the boards can be manufactured quite definitely does. As we will see shortly, these examples are all true examples of the type of thing that can now be undertaken with the aid of a home micro.



For example, a system for the production of circuit diagrams is a CAD system in either sense, but one which mathematically models electronic circuits and predicts their performance is CAD only in the design sense.

CAM stands for 'computer aided manufacture'. There is again some overlap here in that anything which contributes towards the production of a final product could be considered to be CAM equipment. In order to genuinely qualify as CAM equipment though, the system must contribute in a fairly direct way towards the manufacture of a finished product. A system which

generally means printing out on a dot matrix printer, or plotting on a plotter. Most low cost drawing programs are intended for use with a dot matrix printer, and in some cases optional plotter driver software is available. The Lintronic is an exception and it will only provide hard copy in conjunction with one of Linear Graphics Plotmate plotters. In common with most CAD/CAM software Lintronic is only available on disc. Cassette software would not really be very practical in such complex applications where there is generally a menu program which loads other programs, depending on which

SYMBOLISM

On searching for drawing programs specifically intended for use in electronics, apart from printed circuit design packages only one came to light, and this is the Lintronic program for the BBC model B from Linear Graphics Ltd. In order to be of any real value a drawing program must provide some means of providing hard copy, and this

function is chosen (drawing, plotting, printing, or whatever).

On booting Lintronic the user is presented with the usual menu which includes options to create or edit a circuit file or a label file. Having separate disc files for drawings and labels is an unusual feature of Lintronic, but it is a system that is quite easy to get on with in practice. If the circuit file option is selected the user is presented with a screen that has an off-centre cross and a large rectangular cursor. Down the right hand side of the screen is a series of circuit symbols, and these are just a few of the large set of BS3939 based characters. The up and down cursor keys used with SHIFT scroll the character set which can be regarded as a continuous loop, rather like a film strip being drawn past a window down the side of the screen. The character at the centre of the window is shown in inverse video, and this character is drawn at the cursor position if the return key is operated.

This method of selecting characters is very easy to learn, but it can be quite time consuming to find the character you require. No chart to help find the quickest direction to the required character is provided in the documentation, but it would not be difficult to sketch one out. Fast scrolling can be achieved by pressing CONTROL and one of the cursor keys, and pressing ESCAPE causes the set to rapidly scroll to the position where the most commonly used characters (resistors and capacitors) are displayed, but it can still take several seconds to find the required symbol. Things are not helped by the fact that each symbol has to be repeated two or four times so that it is available in any required orientation.

The cursor is moved around the screen using the four cursor keys, with symbols being placed where required. Various lines (including junctions and cross-overs) are available as symbols, but lines can also be drawn by pressing TAB plus one of the cursor keys. This can provide a quick way of joining components, as well as providing a means of producing rectangles to represent integrated circuits. An important feature of any drawing system is some means of deleting errors, and with its symbol system of drawing, things are particularly easy with Lintronic. Simply pressing the spacebar erases any symbol at the current cursor position, or pressing RETURN causes the currently selected symbol to replace any previous one. This is different to most drawing packages where drawing over any existing lines or symbols does not erase them.

The large cross on the screen represents the 'page' boundaries, and there are four pages. Breaking a drawing down into pages is quite a common ploy, and it is a way of overcoming the limita-

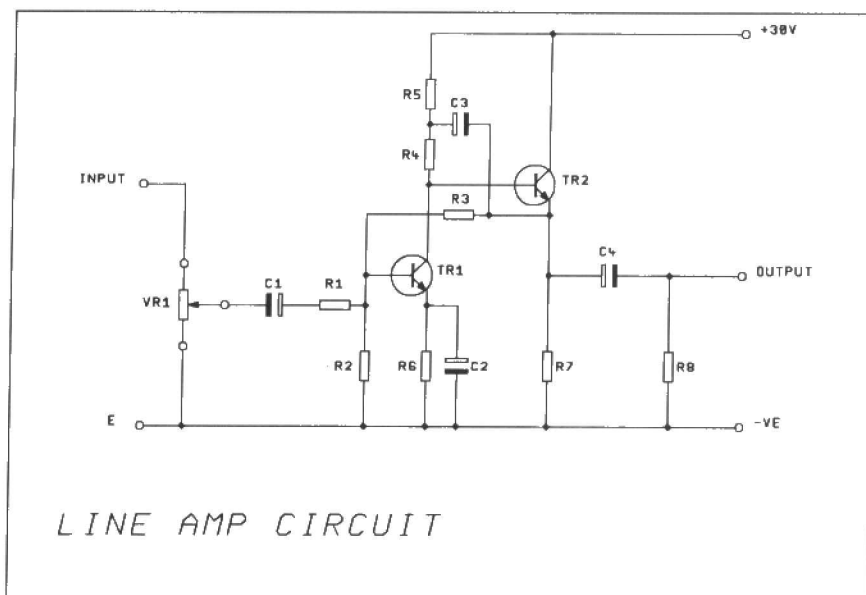


Fig. 1. Line Amp circuit drawn using the Lintronic demo program. As can be seen, the quality is very good. This is reduced on a photocopier however.

tions of having a drawing that consists of just a single screenful. Even with a computer that offers quite high resolution graphics the real resolution is not very good, and complex drawing can not be accurately represented on a single screen display. Up market systems based on mini-computers use a monitor that is more like a giant oscilloscope than an ordinary monitor, and drawings are plotted onto the screen rather like producing lissajous figures on an oscilloscope. Anyone who has seen circles and other shapes produced on an oscilloscope, and circles produced using computer high resolution graphics and a scanning monitor will be under no illusions as to which offers the best results. Unfortunately, the plotting system is well beyond microcomputer capabilities, and the paging system offers a simple alternative.

With Lintronic, taking the cursor close to a page boundary takes you into the

adjacent page with the screen being automatically redrawn. Each page is made somewhat less than a screenful so that part of each adjacent page is shown on the screen, and it is easy to carry the drawing across the boundaries. The obvious drawback of a paging system is that the entire drawing can not be properly viewed at once, but this is a compromise that has to be accepted with any micro CAD system.

The program includes simple but useful editing features which enable columns or rows in the drawing that contain no symbols to be closed up, or the drawing can be opened out to produce vacant rows or columns so that stages can be inserted into the diagram. This enables the drawing to be easily compacted if you start to run out of space, or anything that is overlooked to be inserted without a lot of deletion and redrawing.

Drawings have to be saved to disc

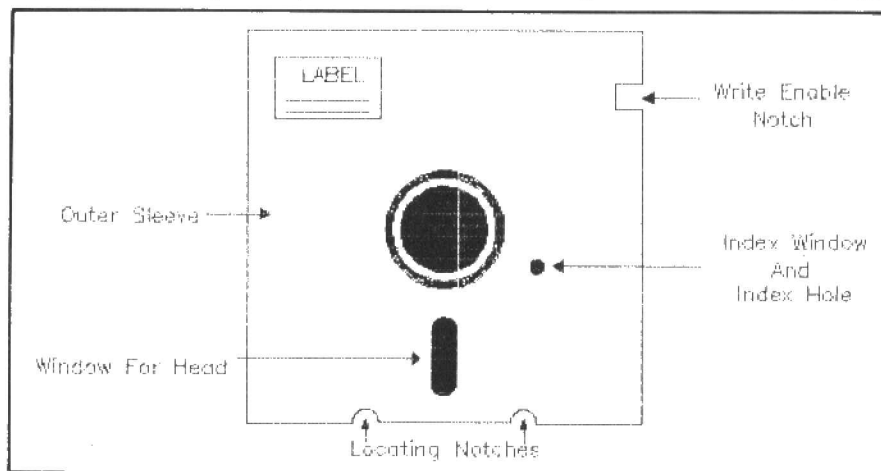


Fig. 2. The DR Draw demo using a dot matrix printer. Its quite good but complicated drawings wouldn't be so readable.

before they can be plotted, and this is a feature which seems to be common to practically all drawing programs. It is due to drawing and plotting or printing being carried out by what are really separate and fairly complex programs, unlike a word processor where printing out is accomplished by what is often little more than a minor routine in the main program.

With Lintronic there is an additional complication in that the labels (if used) have to be added and saved on a separate disc file before plotting a drawing. When the labelling option is selected, the whole of the specified drawing is drawn on the screen, albeit in rather low resolution form. Text can then be added in various widths and heights, with a choice of four orientations, and either upright or with three slant options. Small text sizes are not clearly readable on the screen, and so the text is displayed at the top of the screen. When a label has been entered correctly it is placed on the drawing by pressing RETURN, and a further operation of RETURN confirms it, or SPACE deletes it.

At only £19.50 (excluding VAT) Lintronic is very much at the bottom end of the CAD/CAM price range. It certainly represents good value for money, but it lacks versatility and some circuit diagrams could be beyond the capabilities of its symbol library, even if some ingenuity is exercised. Large circuits can not be handled as a single drawing, but most complex circuit diagrams can be broken down into convenient sections, and are often drawn in this form anyway. The main weakness of Lintronic is that it will only operate with a Plotmate plotter.

RUBBER BANDING

A lot of general drawing programs are not intended for technical drawing and are really painting programs. Those that are intended for technical illustrations fall into two main groups; simple drawing programs that enable good quality results to be obtained but require everything to be entered line by line, and sophisticated programs that have library facilities. DR Draw is a good example of a general drawing package, and it is suitable for any computer which runs under the CP/M 3 operating system and can handle the 'GSX' graphics extension. I used this program on an Amstrad CPC6128 with additional disc drive.

This is an example of a menu driven program where the desired options are selected by placing the cursor under the appropriate heading at the top of the screen and then pressing the spacebar. In fact most menu options are followed by sub-menus. This type of program is really intended for mouse control, but it works reasonably well (if a little slowly) using the cursor keys, and the

program can be configured for control using a joystick.

A detailed description of DR Draw would be out of place here, but we will take a brief look at some of its more representative features. Line drawing is very simple and it is just a matter of picking the start point and then selecting the finishing point. When moving the cursor away from the starting point a line is drawn from that point to the current cursor position; a feature which, for obvious reasons, is termed 'rubber banding'. Various line types are available in addition to the default style of solid lines. A 'snap' facility is included, and this is where the cursor jumps to points on a grid rather than moving pixel by pixel. This makes drawing much faster and easier when high definition is not required, but the cursor can be moved in between snap points if greater precision is required. The grid of dots can be displayed on screen, or not, as desired.

part of the drawing. If you are used to the rapid vertical and horizontal scrolling of a word processor the panning facility of drawing programs tend to be something of a disappointment, being very slow and cumbersome by comparison.

Text can be entered in the machine font, or a variety of alternative styles (fonts) are available. There is a SCALE function which can be used to enlarge or shrink text strings, and this can also be used on other elements of the drawing. In fact non-text elements can have their vertical and horizontal scaling altered by different amounts so that a square can be made into an oblong, and circles can be squashed into ellipses.

MOVE and COPY are two powerful editing commands which have largely self explanatory names. MOVE enables part of the drawing to be selected and moved to any desired area on the drawing. COPY enables the selected drawing element to be copied and then

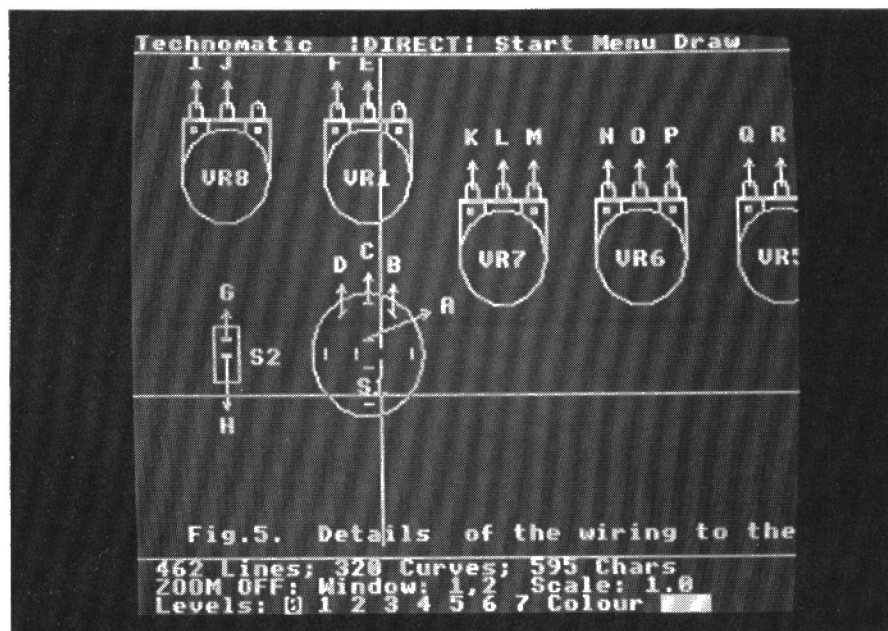


Photo 1. A typical screen showing the Technomatic software.

Circles can be drawn simply by picking the centre and any point on the circumference. Arcs require three points to be selected (the centre, start, and finish). Polygons can be drawn by selecting the corners, and enclosed shapes can be filled in a variety of fill styles (but not all printers and plotters support the full range of fill or line styles).

DR Draw does not use a system of paging, but has the alternative of pan and zoom. The zoom facility enables a small area of the screen to be selected and displayed at the full screen size so that fine detail can be added to the drawing. The pan facility enables the zoom window to be moved vertically, horizontally, or diagonally to another

placed on the drawing in any desired position. COPY differs from MOVE in that it leaves the original drawing element intact, and as many copies as desired can be placed on the drawing.

In some ways DR Draw is a little slow and awkward in operation, and it gives the impression that the Amstrad CPC6128 is barely up to the task of running it. At a VAT inclusive price of £49.95 it represents exceptional value for money since it has many advanced features and includes driving software for printers and Hewlett Packard or compatible plotters.

LIBRARIES

Much drawing work involves the use of elements which have to be drawn time

and time again, and such things as circuit diagram and printed circuit component layouts obviously fall into this category. With most general drawing packages each symbol has to be redrawn each time it is needed. With more advanced drawing programs it is possible to have libraries of symbols which can be loaded from disc and merged into a drawing. These symbols are often called 'icons' or 'macros', and are analogous to rub-on transfers or stencilling in conventional drafting. A library of symbols is the basis of the Lintronic program, but with general CAD packages there is the versatility of being able to define whatever icons are required, and all the normal drawing facilities are also available.

The Novacad program from Technomatic is one which supports this facility. This program will run on the BBC B, B+, B+128, and Master 128 machines, and there are two versions; one for keyboard control, and one for mouse or trackerball control.

There are usually some restrictions on the size of icons, but Novacad is very good in this respect in that icons can have up to 500 lines, and a maximum of 1000 icons or 60k of data (whichever limit is reached first) can be stored on each library disc. Icons can be called up by pressing function key 0 and then giving the appropriate name, or they can be assigned to particular function keys and then called up just by pressing the appropriate key. Once called up an icon can be rotated, mirror imaged, moved, and changed in scale before finally being left in place. The program includes a form of copy facility, and this can be used to copy an icon or any element of the drawing and repeat it on the drawing as often as desired.

Novacad has other interesting features, including the use of a 4 wide by 5 high page system which enables quite large and complex drawings to be produced, although if hard copy is to be produced by a printer it must be a wide carriage type having a condensed mode in order to accommodate all twenty pages. There is a utility which enables the whole drawing to be viewed on-screen, but obviously in only a very low resolution form, and text characters for example, just appear as single pixel dots.

Another advanced feature of Novacad is its ability to handle layers. Up to eight layers can be used, and the main purpose of this facility is to match layers of the drawing with different pens of a multi-pen plotter. This enables multi-coloured drawings to be produced, and (or) different parts of the drawing can be plotted using pens of different thicknesses.

Hard copy can be produced on a printer having Epson compatible graphics using the built-in printer driver, or to a range of plotters with the optional

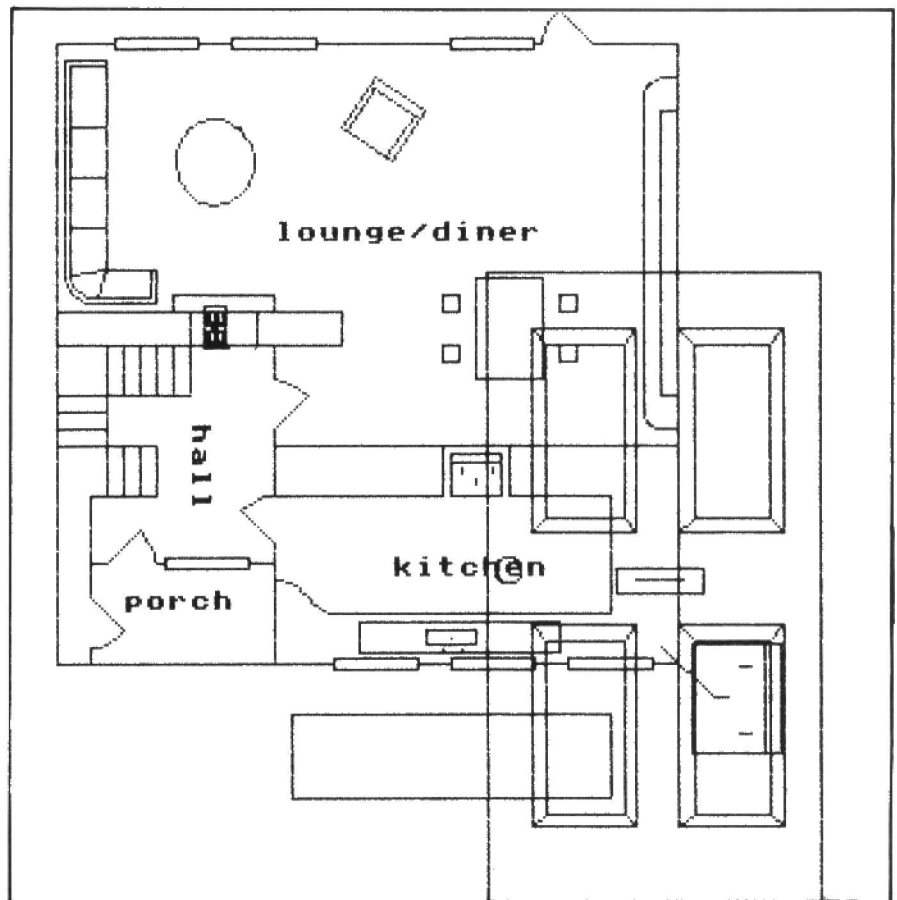


Fig. 3. The NovaCad demo drawing using a dot matrix printer gives excellent results. As can be seen, fairly complicated drawings can be produced.

plotter utility program. The most simple drawing programs provide hard copy using a screen dump which is very quick and easy, but gives a drawing of only equal resolution to the screen display. More sophisticated drawing programs such as Novacad have to store the drawing in a form which offers higher resolution than a single screen display. This is not normally done in the form of a giant memory mapped display, but in the form of a plotting file. In other words, a line drawn from point A to point B would be stored in memory and on disc in a simple coded form as a line from co-ordinate set A to co-ordinate set B. For this reason you can not simply fill the screen with lines and text characters, and there is a limit to the number of lines and text characters that a drawing can have.

A drawback of this system is that it tends to result in redrawing on-screen being rather slow, particularly in the case of circles and arcs where the program takes the basic data and then calculates pixel by pixel what to plot on the screen. It does give data in a form that is convenient for producing hard copy on a plotter, but not where output is to be via a printer. Simple Novacad drawing can be directly output to a printer, but drawings which occupy more than one page must first be processed and stored

on disc as a printer file, and then printed out from this. Production of the printer file seems to be a rather slow business (I thought for a while that the computer had crashed when I first tried out this facility), but by graphics standards things are quite rapid when it comes to the actual printing out. I must confess to being a little disappointed at the drawing quality using a dot matrix printer, and this applies to other drawing programs I have tried and not just Novacad. Much higher quality output would probably be obtained using double or quad density modes, but few drawing programs seem to support these.

PLOTTING

Even an inexpensive plotter will provide much higher quality results than a dot matrix printer, and excellent results can be obtained from Novacad. The plotter program is ready configured for use with the Epson H180, Hitachi 672, and Penman plotters, and it has the unusual feature of enabling the user to configure it for use with other plotters. The programs described in this article are all supplied with good documentation apart from the Novacad plotter utility with its three badly photocopied sheets of instructions. These give little help to anyone trying to configure the program themselves, but with a lot of

trial and error and a little trigonometry we did eventually get the program fully operational with a Plotmate A4M plotter set to its Watanabe emulation mode.

The plotter utility is very straightforward in use, and it gives considerable control over the size of the drawing, enabling small drawings to be brought up to the full paper size, or large drawings to be condensed if desired.

The Novacad package is not without one or two weaknesses, such as a single text size and slow operating speed with large drawings, but it also has some powerful and attractive features. At VAT inclusive prices of £90.85 for Novacad (£113.85 for the mouse/trackerball compatible version) and £32.78 for the plotter utility this software is certainly not overpriced.

PCB DESIGN

With printed circuit boards tending to become ever more complex and intricate it is probably in this area of electronics that CAD/CAM has the most to offer. There are quite sophisticated systems for the IBM PC etc. which offer facilities such as auto-tracking, and have prices of around £10,000 just for the software. Perhaps of more relevance to this article there are low cost but very useful systems for the expanded BBC machine or the Master 128.

Simple printed circuit design programs have many features in common with ordinary drawing programs, but there are two essential differences. One is simply that rather than drawing circles and lines, drawings are built up from tracks and pads of various sizes. The second and very important difference is that the hard copy is at an accurate 1:1, 2:1, or 4:1 scale so that it can be used for the production of boards.

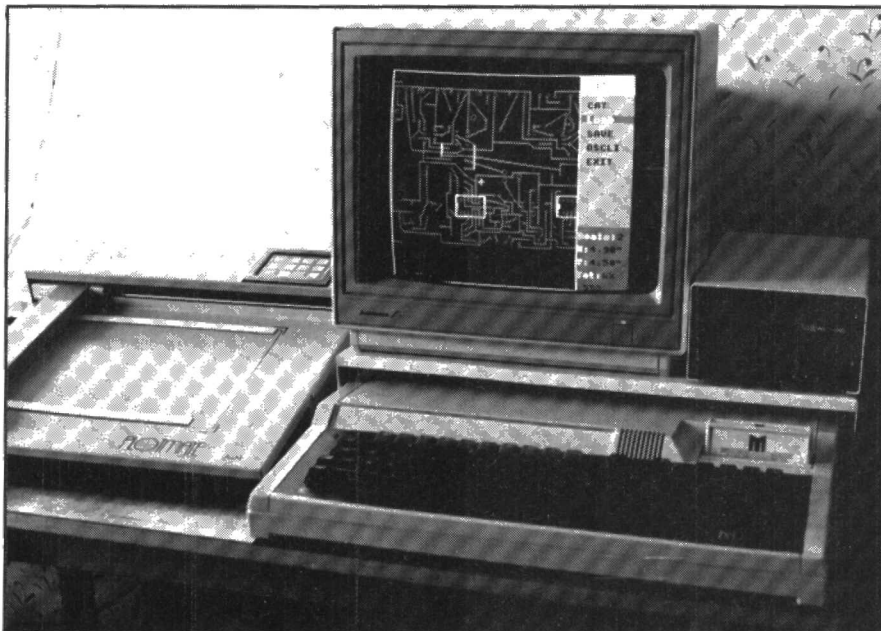


Photo 3. A home-CAD set-up.

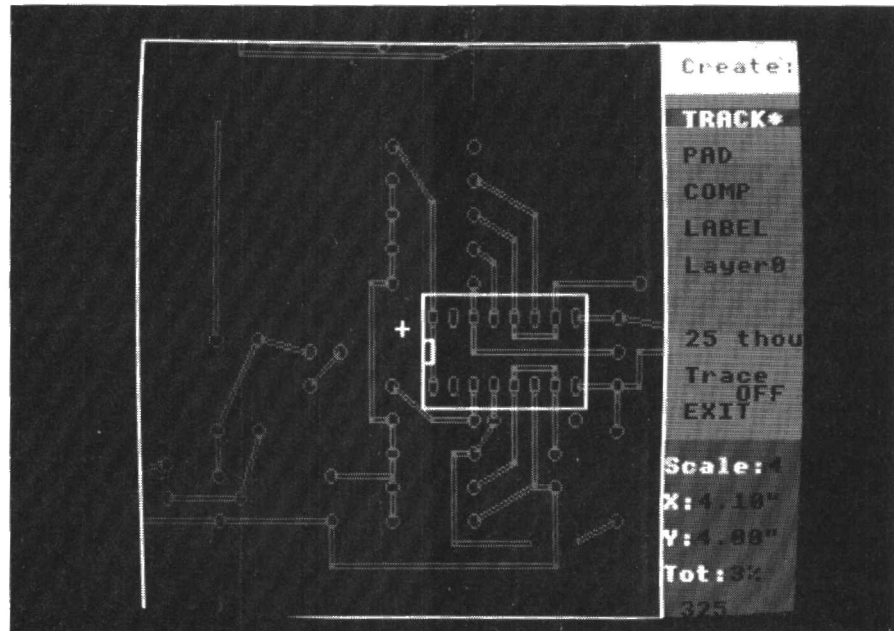


Photo 2. P.c.b. design in action.

The PCBCAD program from Micronova was probably the first low cost printed circuit design program. It will run on a BBC model B with the 6502 second processor, or in a somewhat limited fashion using an Aries or Watford RAM extension. It supports a wide range of track and pad sizes, and the four colour screen display enables double-sided boards to be produced. Boards of up to two feet square can be accommodated with pads and tracks being positioned on a 0.025 inch grid. The more relevant limitation is 5000 'structures' (pads, and tracks) if the 6502 second processor is used, but only about 900 using an Aries or Watford RAM card. Output is produced on an Epson or Epson graphics compatible printer.

This has the advantage of low cost, and many owners of BBC systems probably already have a suitable printer. It has the disadvantage that only accurate 2:1 or 4:1 camera ready artwork can be produced, and the 1:1 output is not adequate for the direct production of a prototype board.

PCBCAD costs £139.00 plus VAT, which may seem expensive, but is peanuts by printed circuit design software standards. A demonstration program is available for £5.00 plus VAT.

REAL CAM

Lintrack is a recent rival to PCBCAD, and it has a number of attractive features. It provides hard copy via one of the Plotmate range of plotters, and this enables accurate drawings at 1:1 to be produced in addition to 2:1 and 4:1 drawings. The plotmate plotters can be fitted with technical pens via an adaptor, and this gives lines of adequate density on drafting film for the direct production of boards using photo-resist copper laminate and an ultraviolet lightbox. In fact I found it possible to plot simple designs straight onto copper laminate board using an overhead transparency pen (which has an oil based ink that works well as etch resist). Quite definitely CAM rather than CAD.

The four colour screen display and multilayer capability enables double-sided boards to be designed, and the maximum size is 10.23 by 10.23 inches with 0.01 inch resolution. Up to 8192 structures can be included on each drawing, and the program permits simple labelling and component outlines to be included as well as a limited but useful range of pad sizes and track widths. The program is controlled by menu selection using the cursor keys,

and learning to drive it is very quick and easy. The manual is only some 30 pages in length, but with drawing programs a large manual is as likely to indicate that the program is difficult to use than that it is comprehensive and well documented.

Probably the most attractive feature of Lintrack is its powerful editing facilities. It has a library facility, and is supplied with a library disc which includes DIL clusters and various types of connector. The user can add to the library which is not restricted to simple DIL clusters and the like, but can contain predesigned circuit blocks if desired. Library objects can be moved, rotated, and duplicated before being 'dropped' into position. When designing my first board using Lintrack I produced it as two separate boards. The second of these was turned through 180 degrees and moved to the top of the screen, after which the first board was loaded into the drawing, moved into position back-to-back with the other board, and then merged with it by adding the necessary interconnections.

The editing facilities can also be used on existing parts of the drawing. An adjustable rectangle on the screen can be used to select all the objects within its boundaries, or the user can go through them one by one, selecting each one for inclusion in the group edit or leaving it out, as desired. Items for group editing can be selected one at a time using the cursor if preferred. These editing facilities enable unwanted gaps in the drawing to be easily closed up, or space to be opened up for any components that need to be squeezed in – the type of thing that is difficult and time consuming with conventional drawing methods. The editing, and the program in general for that matter, operates at an impressively fast speed.

Displaying the whole drawing on screen gives rather poor resolution making checking difficult. Zoom ratios of 2, 4, and 8 to 1 are available, but except for very small boards these will not display the entire board at once. The plotting part of the program has provision for producing a quick outline plot for checking purposes, and I found spotting and correcting errors very easy with the aid of this. My first board was error-free and worked first time, and Lintrack is certainly a piece of software that can be wholeheartedly recommended.

Although Lintrack is easily the most expensive of the programs covered in this article at a price of £250.00 plus VAT, there are programs for the IBM PC and compatibles at three to four times this price which seem to offer little more for the extra outlay, and seem to be inferior in some respects. Bear in mind though, that ideally a BBC Master 128 or B+128

computer plus twin drives is needed to run the program, but it can be run on upgraded model B and B plus computers with a single disc drive. Another point to keep in mind is that the program will only provide hard copy on a Plotmate plotter. A demonstration program is available for £12.50 plus VAT, and this is apparently the full program but with a limit of 500 structures (which seems a bit generous and makes it the bargain of the century for anyone who produces lots of small to medium size boards).

performance of complex networks of components connected in any configuration the designer chooses is quite another matter, and is something that has been very much the domain of mini computers in the past. I therefore approached Analyser II with some scepticism half expecting it either to show some weaknesses on difficult circuits, or to take about a week to produce each set of results.

For such a complex and technical program it is certainly very easy to use,

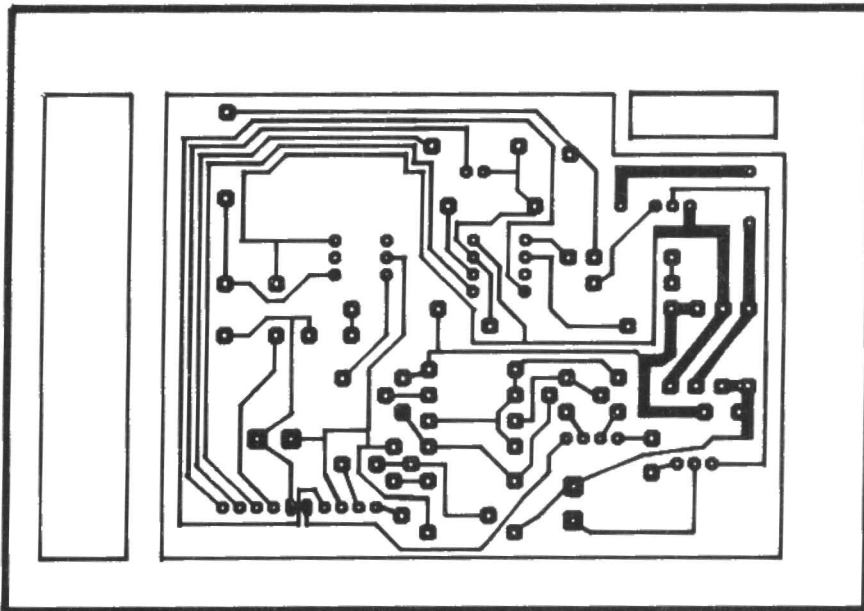


Fig. 4 A Lintrack p.c.b. design shown here slightly less than actual size.

MODELLING

A company called Number One Systems produced an excellent low cost drawing program for the BBC model B and a dot matrix printer, but their main claim to fame is their Analyser programs. The particular version I have used is Analyser II for the BBC model B (a faster and more advanced version is available for the IBM PC and compatibles). The purpose of Analyser II is to mathematically model a circuit and predict its performance at various frequencies. It is not a so called expert system, and it will not design a 1kHz third order lowpass filter (or whatever) for you, but it will test a design you have created. Amendments can be made to the circuit which can then be rechecked, and this process can be repeated until the circuit is finally perfected and proved without ever having built it. Well that is the theory anyway. A program of this type also lends itself well to modelling maximum and minimum real circuit values so that worst case effects of component tolerance can be predicted.

Mathematical modelling of logic circuits is not too difficult, and various types of filter and amplifier can be modelled using the appropriate formulas. Accurately predicting the AC

and the on-screen prompts and menus ensure that only occasional reference to the manual is needed. The components that can be modelled are resistors, capacitors, inductors, bipolar transistors, field effect transistors, operational amplifiers, and transformers, which seems to cover most eventualities. With the active devices there are six default devices of each kind, but the parameters can be altered so that any desired types can be modelled. Circuits having up to 100 components and 27 nodes (component junctions) can be handled.

Circuits are easily entered into the program, and the first step is to draw the circuit, including type numbers, values, and numbers from 0 upwards for the nodes. Fig. 1 shows a twin T filter circuit which I used for an initial test. The circuit is entered as a table which gives the identification number of each component, the nodes to which it connects, and its value. The circuit is unfussy about the form values take, and as an example, 3k3 could also be entered as 3300, 3.3E3, 0.0033M, or M0033. Once all this information has been given, entry of the circuit is terminated by designating the nodes which act as the input, output, and ground. As this is an AC analysis program it makes no DC

checks, and it is up to the circuit designer to ensure that proper biasing is provided where necessary. For AC signals there is assumed to be zero impedance across the supply rails, and any components which connect to the non-earthly supply rail should be connected to the earth node for analysis purposes.

In order to analyse a circuit the start and finish frequencies must be given, and either logarithmic or linear scaling is selected. Up to 45 steps are available, which will not be sufficient in all cases. However, by breaking the response down into narrow frequency bands and analysing them separately this shortcoming is easily overcome. The circuit normally plots gain and phase response, but it can also be set to show input impedance, output impedance, and group delay. Results are first shown in tabular form, and then a simple graph display can be produced if required (Fig. 2). Both tables and graphs can be dumped to a dot matrix printer if required.

Results with the program are certainly impressive. The response of the T notch filter was plotted accurately, and on modifying the circuit to put the filter in the feedback loop of an operational amplifier the correct bandpass response was reproduced. In fact a variety of circuit types were tried with no errors

coming to light. Checking the results of Analyser II against real circuits and test results will produce discrepancies, but even using close tolerance components, any discrepancy can be largely attributed to the real circuit and not any lack of accuracy in the program. Although results may not seem to be produced lightning fast, with each step typically taking a second or two, considering the complexity of the calculations involved this is actually surprisingly fast.

Analyser II is certainly an excellent program which anyone involved in the design of analogue circuits should find extremely helpful. At £149.50 for the BBC version and £224.25 for the IBM version it is quite expensive though, and the lower cost Analyser I program would probably be of more interest to most potential users. This can handle fewer components and only provides tabular output. Versions for the Spectrum 48k, BBC model B (cassette and disc) and IBM PC are available at prices from £23.00 to £74.75.

CONCLUSION

In this article it has only been possible to take a brief look at some representative CAD/CAM software, but this should be sufficient to give a good idea of the types of application that can be handled. It is still early days as far as

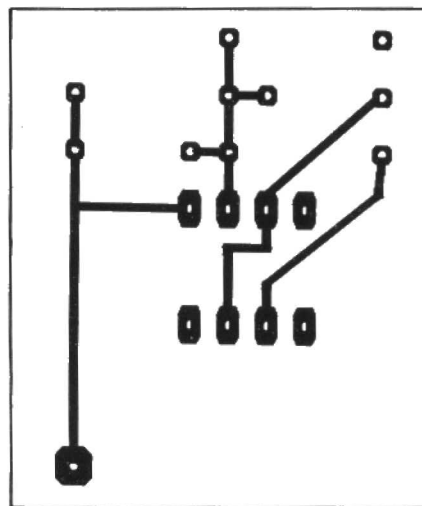


Fig. 5 Lintrack p.c.b. 2:1 ratio.

micro CAD/CAM software is concerned, and it is an area of computing which has not received the same degree of effort as say business or games software. As time passes the software and hardware will probably both become more sophisticated and less expensive, but even as things stand there is a significant amount of reasonably priced software and equipment available, and simple CAD/CAM systems are genuinely useful and not just toys. **PE**

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COMMENT . . .

Women in Science – The Screwdriver Versus the Knitting Needle

GIRLS are happier studying needlework while boys prefer to learn engineering. I am forced to agree and I am a female student about to read Physics at university.

The discomfort endured by any girl fighting her way into a career in science is more than enough to put most of us off. And I am not simply referring to the way the women's toilets are miles from the labs in most polytechnics.

No, I am thinking of the everyday brainwashing inflicted on the fairer sex to preserve our delicate dishwashing hands from the filth of a car engine. Which reminds me – how many television advertisements have you seen where a man cleans dishes or frets over the stains on his wife's unboilable cotton shirt? But the really frightening fact is that when we do see some chap bent over the sink, we think it is an unusual gimmick.

What would be your reaction to a civilization where children are brought up for their future jobs, where electric shock treatment forces them to hate any alternative careers? This is our future as foretold by Aldous Huxley in his book *Brave New World*. People are even trained to take pride in their position in society. Mankind is reduced to a flock of conditioned sheep.

But today's methods of teaching children to relish their future roles are much subtler and just as effective. Consider the words of praise showered on little Tommy when he hammered his first toy nail. They were almost as warm as the 'aaah's' when his sister presented 'Cindy' decked in her finest togs.

In true Huxley style, children are tied by their clothes into fashions of behaviour. Next time you see a five-year-old girl strutting along in imitation court

shoes, a flouncy skirt and heavy earrings, try to picture her wielding a spanner one day. What is more, a girl must be specklessly clean to look appealing, while if a boy manages to smother himself in dirt, his Mum only laughs "Oh isn't he a cheeky rascal".

The really ironic twist, however, is that the girl insisted on buying those shoes and she pestered for a 'Cindy' doll for weeks. Once again, a television advertisement was probably to blame.

The child saw the doll cradled in the arms of a meticulously groomed little starlet who was obviously excessively happy. So the advert is not just selling dolls, it is hammering the idea that happy little girls spend their day wearing beautiful clothes and showering Cindy.

Perhaps the next advert showed two lads in dungarees lying on the floor and racing wind-up robots. Since children aged five watch an average of two to three hours television every day, the psychological enforcement from this source must be at least as effective as Huxley's electric shock.

The female scientist faces an uphill struggle. After a bad start, the prospects only get worse. If there is any mechanical bent left in her, school will straighten it out. According to an Open University programme on education, teachers spend far more time with the males in the class than the females. Perhaps the females make less noise. The surprising result was that even when this was pointed out and teachers were told specifically to spend more time with girls than boys, they STILL focussed on the males. Why? Does this put forward a case for single sex science lessons?

It is perhaps not so surprising, therefore, that two thirds of the successful Oxbridge candidates are men.

Indeed I am amazed the fraction is not higher. The figures are a lot more sexist if you consider the subjects undergraduates are reading. Imperial College in London offers only science degrees. The ratio of men to women is eleven to one, which is exciting for the women at Imperial, but does not say much for our entry into technology.

Does this reflect a natural tendency by boys towards science and girls towards the arts? Psychological research shows that there is no difference between male and female reactions to science problems until the age of thirteen; and that any difference that ever develops is probably due to training since an inherent difference would surely show up much earlier.

Suddenly a call has gone out for more women scientists. The people already working in technology – which is another way of saying 'men' – are advertising for the female touch.

What a hypocritical plea!

Any woman who has enough determination to qualify herself for a career in engineering despite her education, needs no patronising words of encouragement. By attacking the problem when the damage has already been done, men can rest assured that their supremacy in science is not threatened. But at the same time, justice is seen to be done and women are apparently given a chance.

And because so few women come forward, the men sit comfortably in front of their computers and sigh, "they obviously prefer needlework."

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DC CONTROL OF ANALOGUE SIGNALS

L. SAGE

Useful techniques and circuit ideas

Despite the increased use of digital integrated circuits in analogue audio devices, d.c. control is still widely used and has hundreds of applications.

CONTROL of an analogue signal has traditionally been by way of a standard potentiometer, whether this be an audio volume control, tone control, or a more complex control such as is used on a mixing desk or a music synthesiser.

An increasingly common requirement in today's Hi-Tech electronics systems is d.c. or remote control of analogue signals. The earliest and most common application of analogue signal control using a d.c. control potential is of course in the domestic TV receiver. This requirement came about due to the market needs for remote control TVs.

Since the TV market is so vast, semiconductor manufacturers were quite happy to invest large sums of money generating dedicated i.c.s particularly for this purpose. Most of these i.c.s however contain a lot more than just the d.c. control circuits and in some cases about half of a modern TV. Only relatively recently have manufacturers released useful i.c.s for the general electronics industry. It is not the purpose of this article to explain these i.c.s and their uses – most of their information can be obtained from the manufacturers' data sheets. This article is mainly concerned with demonstrating that for many cases simple d.c. control can be achieved using standard, low cost, easily obtainable, discrete components.

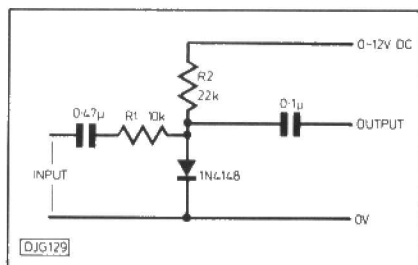


Fig. 1. Diode control

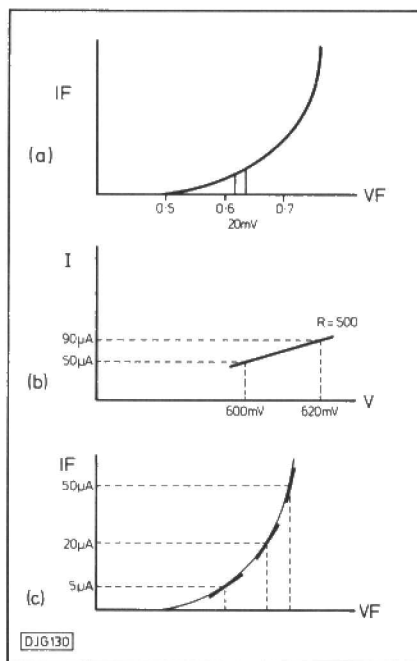


Fig. 2. Characteristics

Nowadays, with even the simplest of electronic gadgets, a microprocessor is often at the heart of the system and this often needs to control external analogue signals. It is also undesirable to route audio signals around in the same box as a micro due to the chances of picking up spurious digital noise.

Using a d.c. voltage to control the signals' parameters allows the designer to position the controls where he wishes on the front panel.

The most difficult problem of d.c. controlling a signal is that of distortion. The signal itself to be controlled is a varying signal and hence will have a tendency to modulate the control voltage and then in turn modulate itself.

Fig. 1 shows a very simple method of gain control using a diode as a variable resistor. It may seem strange to apply the audio signal directly across a diode

in this manner as one would imagine the diode to simply clip off one half cycle. This is true for large signals, however, if the signal level is kept at a fairly low amplitude, typically less than about 10mV RMS, then the diode acts as a fairly linear resistor. Fig. 2 shows this, and it's clear that varying the diode's current will cause a change in the slope of the V/I characteristics and therefore a change in its forward resistance. The value of the diode's forward resistance is approximately $25/I_f$ where I_f is the diode's forward current in milliamps.

The distortion generated by this circuit is surprisingly low at around 0.2% and the amount of attenuation is determined by the ratio of R_1 to the diode's forward resistance. Typical attenuation levels range from 0db with zero control current to better than -50db dependent upon the control current and the value of R_1 . Varying the control potential will vary the current through the diodes and hence alter their forward resistance.

The actual amount of distortion produced is very dependent upon the signal amplitude and is predominantly 2nd harmonic in nature. If a larger signal than 10mV RMS is to be controlled, then two diodes may be used as in Fig. 3. This circuit gives some measure of distortion cancellation allowing a signal of up to 40mV RMS to be controlled with less than 0.2% THD this time predominantly 3rd harmonic. As a matter of interest a 50% reduction in signal amplitude causes a 5 fold reduction in distortion.

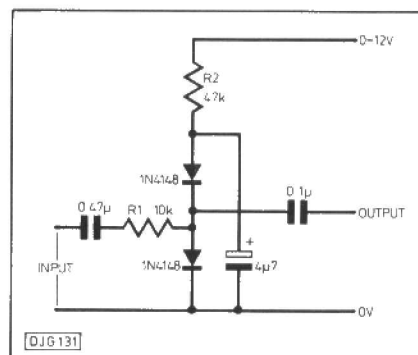


Fig. 3. Distortion cancellation

Still further reduction in distortion and greater signal handling can be achieved by using two diodes in series in place of each diode as in Fig. 4. This circuit will accept up to 80mV RMS and there's no reason why this technique cannot be extended further by adding more diodes.

SERIES TYPE ATTENUATORS

The circuits so far described are all shunt attenuators, however a series type attenuator can be built and a common type is shown in Fig. 5. Again this circuit will only work satisfactorily with low levels of signal at around 10mV. Since

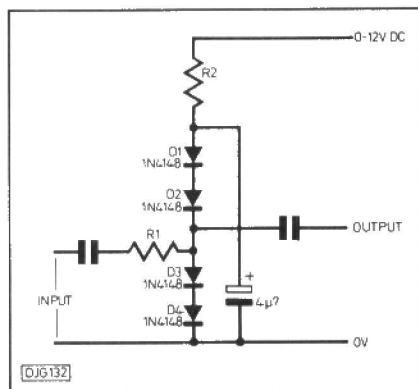


Fig. 4. Further cancellation

both diodes act as variable resistors, there is a different level of signal amplitude across each diode and hence the distortion cancelling properties are not as good as in the shunt type.

Fig. 6 shows an alternative series circuit, one which I prefer as the signal level across each diode is equal and therefore distortion cancellation occurs.

It's now worth looking at the advantages and disadvantages of the series versus the shunt type.

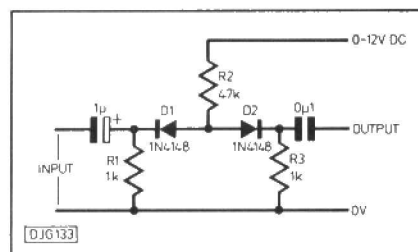


Fig. 5. Series attenuator

The shunt type has the greatest signal handling capability provided the signal across the diodes is kept below the levels described earlier. This is because the input signal during attenuation appears across R1 and only the output signal appears across the diodes. The polarity of the shunt attenuator is positive ie, an increase in control voltage will cause an increase in signal attenuation. The shunt type however does have only a limited amount of attenuation capability and

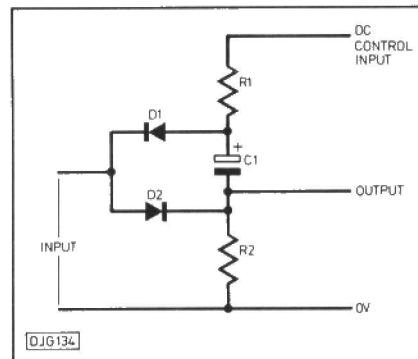


Fig. 6. Preferred circuit

greater attenuation can only be had by cascading two or more stages.

The series type on the other hand has a relatively poor signal handling capability. At high levels of attenuation the input signal appears across the series diodes. Therefore unless the input is kept below the previously described levels, distortion will be produced. It does however have the capability of a much greater level of attenuation typically better than 80db and has a negative polarity ie, increasing the control voltage reduces the attenuation.

desirable aspects of each circuit. The signal is first attenuated by the shunt circuit with its good signal handling properties and then it meets the series type at a much reduced level. The series circuit then provides the level of attenuation without any overload problems.

Fig. 8 shows a simple d.c. controlled tone control. This circuit will provide up to 12db of bass boost and 15db treble cut dependent upon the d.c. control voltages. The input will accept audio at around 300mV RMS, the output level being around 80mV. The amount of bass boost provided is dependent upon the relative values of R1 and R2 and the turnover frequency dependent upon the time constant of R1 + R3 and C3. The treble turnover frequency is dependent upon the time constant of C5 and R3.

Fig. 9 shows how the diode attenuator circuit can be used as an amplitude modulator and so produce at a very low cost the well known 'Tremelo effect'. T1 is connected as a phase shift oscillator and generates a low frequency sinewave, this is then impressed upon the d.c. control voltage to modulate the audio signal.

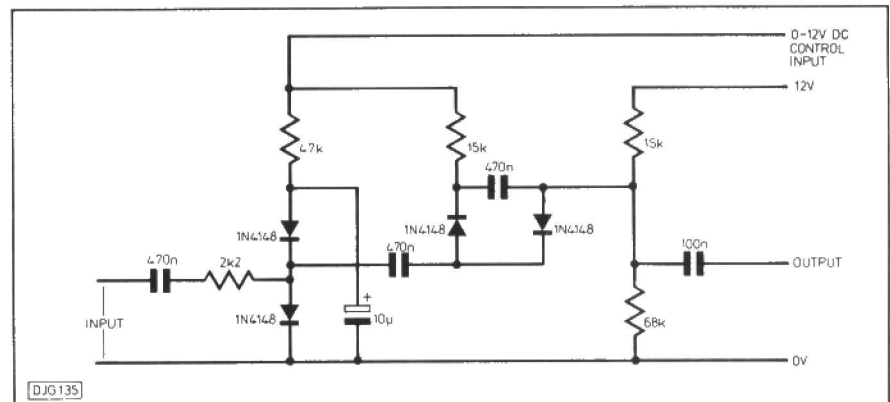


Fig. 7. Combined short and series circuit

The polarity can however be reversed as shown in Fig. 7 which also shows how the properties of a shunt type can be combined with those of a series type to produce an attenuator with all the

Those keen eyed constructors may have noticed that the phase shift oscillator has four time constants instead of the usual three. This has the added advantage that four time constants each

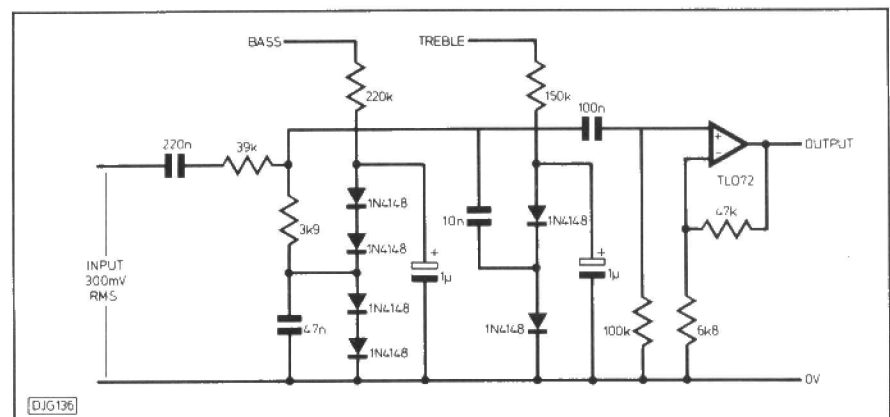


Fig. 8. D.C. controlled tone control

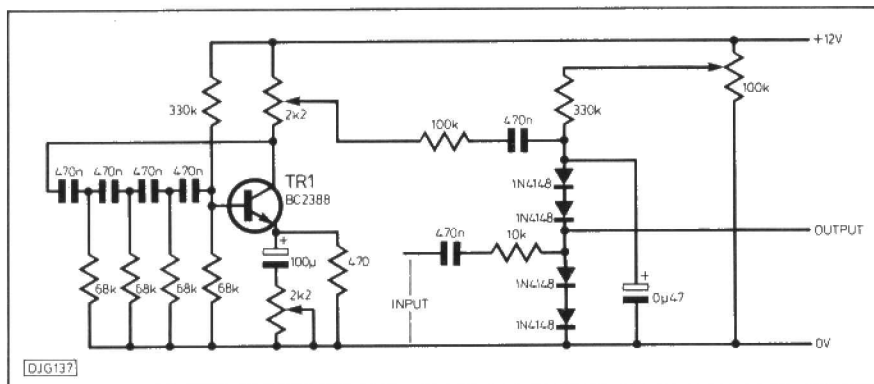


Fig. 9. Amplitude modulator

contributing only 45 degrees phase shift give less overall attenuation than the more usual three at 60 degrees. TR1 therefore does not have to supply as much gain and hence it is much easier to control its gain more accurately.

The circuit shown in Fig. 10 is of the familiar 'All Pass' filter or constant amplitude variable phase filter. It is used in several different musical effects units ie the 'Phasor' and also the 'Flanger'. The phasor unit consists of two stages cascaded and hence gives a maximum phase shift of 360 degrees. The flanger unit, however, consists of at least six stages cascaded and sometimes even more. The effect of this phase shifted signal when added to the original signal is to produce a series of alternate signal additions and cancellations across the frequency spectrum. This circuit is often called a comb filter due to the comb-like frequency response.

The main problem with each of these circuits is that to produce the required sound effects the phase shift has to be variable under user control. With six or more stages it is impractical to have a six gang pot and therefore d.c. control is essential. One or two circuits have been published in magazines in the past and the most common method of adjustment appears to be by way of Light dependent resistors (l.d.r.s) in place of R1 and l.e.d.s placed close to them. The control voltage is used to drive the l.e.d.s and therefore vary the l.d.r.s resistance. l.d.r.s are quite expensive and it's often

thought a rather clumsy way of providing control.

Some commercial units use FETs to act as the variable resistor element, these too are relatively expensive although less than l.d.r.s but due to the

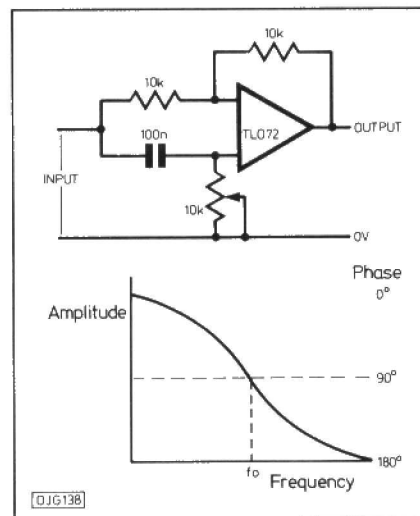


Fig. 10. 'All Pass' filter

very large spread in gate potential, these FETs must be selected to match their characteristics closely.

Fig. 11 shows how the shunt diode attenuator of Fig. 3 can be used as a very cost effective alternative to l.d.r.s or FETs. The diodes, unlike FETs, do not have to be matched and as many stages as one wishes can be cascaded.

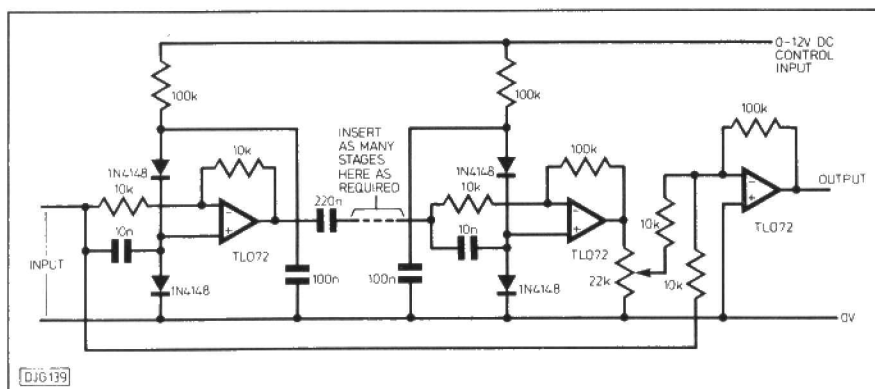


Fig. 11. Alternative to l.d.r.s.

The drive current to the diodes is quite small, just a few tens of micro-amps, therefore they can easily be driven directly from an op-amp connected as either a sinewave phase shift oscillator or as in Fig. 12 as a linear ramp generator.

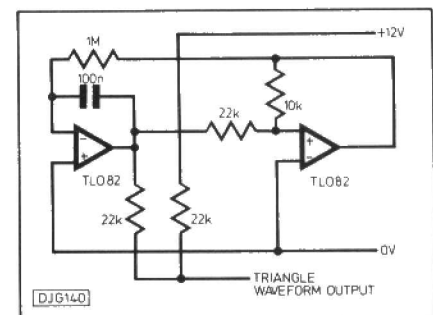


Fig. 12. Linear ramp generator

It should also be pointed out that the purpose of C2 in Fig. 1 is to decouple audio such that both diodes see the input signal equally. Therefore it should not be made unnecessarily large otherwise it will tend also to decouple changes in the control voltage. **PE**

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SPACEWATCH

BY DR PATRICK MOORE OBE

The RGO threat remains

Powerful magnetic fields generated by super-pressurized water and ammonia? Zenithal Hourly Rate about 75? Are Kogler's Comet and Swift-Tuttle one and the same? . . . Read on!

WORK on the new William Herschel Telescope at La Palma continues to make good progress, though obviously the uncertainty surrounding the future of the Royal Greenwich Observatory is casting a shadow over all activities. Opposition to moving the RGO (and, in effect, destroying it) is growing quickly, but the threat remains.

Further findings about the green planet Uranus have been reported as a result of the Voyager 2 mission last January. It now seems that the powerful magnetic field may well be generated by a super-pressurized ocean of water and ammonia lying below the Uranian atmosphere and above the molten core. The atmosphere itself consists mainly of

hydrogen and helium; the average temperature is -219 degrees Centigrade, and the day side of Uranus radiates a large amount of ultra-violet light, making up what has now been called an 'electroglow'. It has also been found that the polar and equatorial temperatures of the planet are much the same, though at present the tilt is pole-on toward the Sun.

Voyager 2 is on its way to a rendezvous with Neptune in August 1989, and seems to be in good shape. Meanwhile Giotto, having survived its encounter with Halley's Comet, is on a path which will bring it back to the neighbourhood of the Earth in July 1990. Some of the experiments are still functional (though



at the moment they are switched off), and it may even be possible to send Giotto on to a rendezvous with the periodical comet Grigg-Skjellerup in 1992, though much depends upon how badly the main equipment is damaged.

THE PERSEIDS – AND COMET SWIFT-TUTTLE

August is the main 'meteor month' of the year. We are passing through the annual Perseid shower, and a good display always occurs. The ZHR or Zenithal Hourly Rate is usually about 75, though admittedly this varies somewhat from year to year. (The ZHR is the number of meteors which would be expected to be seen per hour by an observer under ideal conditions, with the radiant at the zenith; in practice, the observed rate is always less than the ZHR, because ideal conditions are never attained.) The shower begins around July 23 and goes on until August

The Sky This Month

AFTER the unusual events of the past few months, we are now returning to what may be termed 'normal'. Both the inner planets are well displayed. Mercury is on view in the morning sky, before sunrise, in the middle part of August. Greatest elongation (19 degrees) occurs on the 11th, and the maximum magnitude will be -0.2 , brighter than any star apart from Sirius (not counting Canopus, which never rises over Britain). Telescopically, Mercury will then appear as a tiny half-moon, though no details on its surface will be seen. It is always finding this quick-moving, elusive little world – but never sweep for it with binoculars or a telescope unless the Sun is completely below the horizon.

Venus reaches its greatest eastern elongation (46 degrees) on August 27. The magnitude is almost -4 , and one can understand why the ancients named Venus after the Goddess of Beauty! It is interesting to watch the phase telescopically; during evening elongations the moment of dichotomy (half-phase) always occurs before greatest elongation – an effect which, years ago, I named the Schröter Effect, since it was first noticed by J. E. Schröter almost two centuries ago. No definite markings will be observable on Venus; all we can see is the top of the cloudy, corrosive atmosphere. Mars, in Sagittarius, is still very bright, though its magnitude drops to -1.8 by the end of the month; Jupiter is coming up toward opposition, on the borders of Pisces and Aquarius, and is visible for much of the night; Saturn is still to be seen in the south-west after sunset, and the ring system is still wide open. Altogether this is a good month for planets – and you can also add Uranus (in Ophiuchus) and Neptune (in Sagittarius) if you have optical aid.

The Moon is new on August 5, and full on the 19th. There are no eclipses this month.

The so-called 'Summer Triangle' (Vega in Lyra, Deneb in Cygnus, and Altair in Aquila) continues to dominate the evening sky, though of course not even Vega can rival the brilliance of Mars or Jupiter, to say nothing of Venus. Ursa Major, the Great Bear, is fairly low in the north-west, with Cassiopeia in the north-east; Arcturus has almost set in the west, and Capella is so low down that it may not be seen (remember that Capella and Vega lie on opposite sides of the pole, and at about the same distance from it). The lovely star-clouds of Sagittarius are still to be seen low in the south-west; it is a pity that from our latitudes they are never seen to advantage. The Square of Pegasus has now risen, and occupies the south-eastern aspect; its four main stars are quite unmistakable, even though they are not particularly brilliant. Leading away from Pegasus is the line of stars marking Andromeda. Indeed, one of the stars in the Square, Alpheratz, is now included in Andromeda, as Alpha Andromedæ; this seems illogical, since it so clearly belongs to the Pegasus pattern, and was formerly known as Delta Pegasi.

Late at night look for Fomalhaut in Piscis Australis (the Southern Fish). Two of the Pegasus stars – those to the 'right' in the Square – point to it. Fomalhaut is the southernmost of the first-magnitude stars to rise in Britain, but it is always low down, and from North Scotland it is difficult to see at all. It is one of our closer neighbours, and has been found to be associated with cool material, emitting infra-red radiation, which may or may not indicate the presence of a planetary system.

20, with a maximum on the night of August 12-13. This year the Moon will not be too obtrusive, though it will interfere badly with the latest stages of the shower.

Despite modern radar work, there is still plenty of scope for the visual observer. Counts and magnitude estimates, as well as tracks, are always of value, and there is a great need for more meteor spectra. Photographing the spectra of meteors is always a hit-or-miss affair, because one can never forecast just when or where a meteor will appear; but the amateur who wants to make a real contribution, and can build the necessary equipment, can play a major rôle.

Many meteor showers are associated with comets. (This includes Halley's Comet, which has now passed beyond the range of amateurs; the 'Halley showers' are the Orionids and the Eta Aquarids.) The case of the Perseids is even more intriguing. We know the parent comet - Swift-Tuttle - but we do not know where it is now!

It was discovered on July 16, 1862, by the famous comet-hunter Lewis Swift, but at first he confused it with another comet which he had observed earlier. On July 19 it was found independently by Horace Tuttle, so that the names of

both discoverers are now attached to it. It came to perihelion on August 23, and was reasonably bright; the nucleus was about magnitude 4, and there was a 10-degree tail. Subsequently it brightened to magnitude 2, and there was great activity in both the nucleus and the tail; by September the tail length had attained 30 degrees. Thereafter the comet faded, and was last recorded on October 31.

The period was worked out to be between 120 and 125 years. Then, in 1866, G.V. Schiaparelli (perhaps best remembered for his observations of the non-existent canals on Mars) announced that the comet was responsible for the Perseid meteor shower. This was the first time that a comet/meteor association had been definitely established, but there is no doubt about it.

THE COMET IS STILL MISSING

In 1889 G. Hayn, of Göttingen, computed an orbit for the comet giving a period of 119.6 years. In 1873 Brian Marsden, at Harvard, made a new calculation and found a period of 119.98 years, in which case the next perihelion date would be September 17, 1998. Searches were made well ahead of time,

but the comet failed to put in an appearance, and at the present moment it is still missing.

Why should this be so? At its 1862 return it was bright, and showed no signs of imminent disruption; also it was quite well observed. Either it has come and gone unseen, or else the calculated period is wrong.

ARE THEY ONE AND THE SAME

Looking back in the comet catalogues, Marsden pointed out that the orbit of Swift-Tuttle was very much the same as that of Kogler's Comet of 1737, which was described as looking 'larger than Jupiter'. If Kogler's Comet and Swift-Tuttle are really one and the same, we arrive at a period not of 120 years, but 125, indicating the next perihelion in 1987. Obviously this is very uncertain, partly because we cannot be sure that the two really are identical, and partly because Kogler's Comet was not followed at all accurately. All the same, it is an intriguing possibility; and this year and next, observers will be on the alert to see whether the Perseids are going to be unusually rich and whether there is any sign of the elusive Swift-Tuttle.

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FIBRE-OPTIC DATA LINK

BY R. A. PENFOLD

Not quite the Omega of Optics but an impressive implementation of computer communication

Computer crashes caused by mains-borne interference in connecting cables can be totally eradicated using this design. In addition, EMI and RFI is non-existent. Apart from these obvious advantages, a fibre-optic link offers a much neater solution to computer communications. Bet your mate hasn't got one.

A SYSTEM to provide a high quality audio link via fibre-optic cable was described in the March 1986 issue of *Practical Electronics*, and this article features what is really a digital version of the original design. It is for use with standard RS232C and RS423 serial ports, and it can handle baud rates of up to 9600 baud. In fact a quick test at 19200 baud (the highest standard baud rate) seemed to give perfectly good results, but the system has not been extensively tested at this rate. The prototype equipment has been used with a maximum cable length of 20 metres, but a range of substantially more than this should be possible, especially if a very high quality cable is used.

As described here the system only provides simplex (one way) operation with no handshake lines being implemented. However, for full duplex operation it would merely be necessary to have a transmitter and receiver at each end of the system, with a twin fibre-optic cable being used to provide cross-coupling. By adding more transmitters and receivers it would be possible to implement handshaking, but serial systems which operate over anything other than very short distances are normally arranged so that the receiving equipment can keep up with data streams from the transmitter, and handshaking is unnecessary (as in modem communications for instance).

As with the original fibre optic link design, it is doubtful if the system has any great advantage over using ordinary connecting cables. It does have complete immunity to electrical interference picked up in the connecting cable, and there is also no radio frequency interference radiated from the cable. Probably the main point in its favour though, is its interest value, and it represents a practical introduction to a subject that has received largely theoretical treatment in the past.

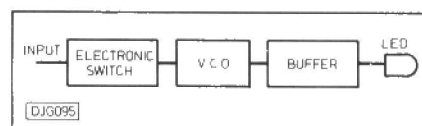


Fig. 1. Transmitter schematic

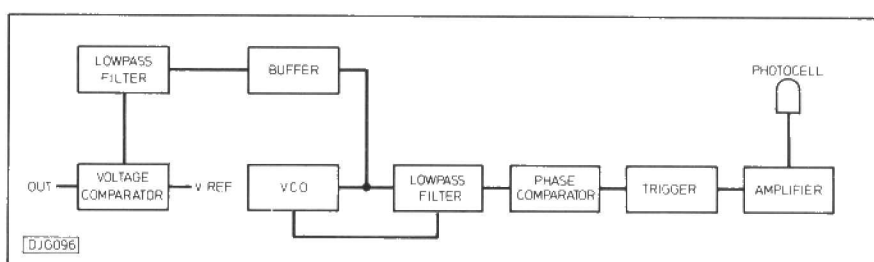


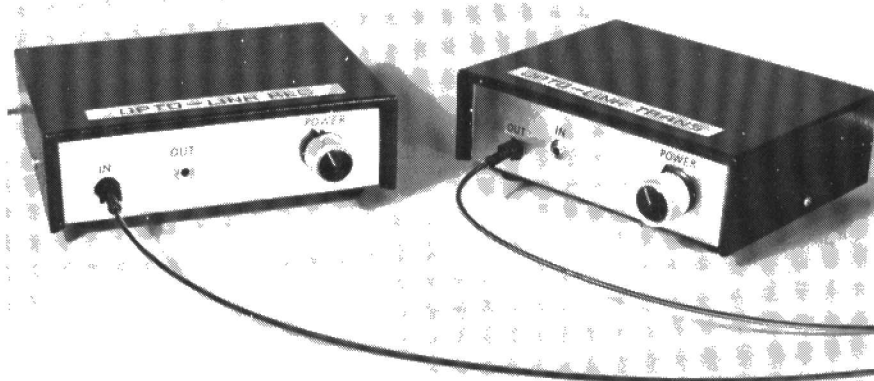
Fig. 2. Receiver schematic diagram

SYSTEM OPERATION

There are two basic approaches to the transmission of serial data, whether the cable is of the optical or the wire variety. The most simple system is a straightforward d.c. connection. In a fibre optic context this involves a light source at one end of the cables and a detector/trigger at the other. Under stand-by conditions the output of the trigger circuit is low, but when the light source is activated it is triggered to the high state. Such a set-up is very simple, but it requires a high degree of efficiency in order to obtain a strong enough signal to drive the receiver circuit reliably. Suitable components are now becoming available to amateur and other small quantity users, but are still rather expensive.

The alternative system is a tone encoding/decoding type, as used in telephone modems. This is more complex, but it has the advantage of treating the receiving photocell as an a.c. signal source and very low level signals can be amplified to a usable level without any drift problems. This gives greater range than a d.c. system for a given pair of opto devices, but at the expense of reduced maximum baud rate. This reduction in baud rate is due to the carrier tones having to be substantially higher than the maximum switching frequency, and the maximum frequency that the system can handle is therefore much less than that which the photocells can handle.

In this design a tone encoding/decoding system has been adopted, and this enables the circuits to be based on



relatively inexpensive opto devices. Baud rates of several megabaud, or even several hundred kilobaud, are beyond the capabilities of the equipment, but this was not considered to be of any great significance since few home computers are guaranteed to operate at even 19200 baud, and some do not support the higher standard baud rates at all.

The transmitter is by far the less involved of the two units, and as can be seen from the block diagram of Fig. 1 it consists of just three main stages. The carrier signal is generated by the voltage controlled oscillator (VCO), and a buffer stage enables it to drive the transmitting l.e.d. at the fairly high current required in this application. An electronic switch at the input of the circuit is driven by the serial input signal, and this just switches the VCO between two operating frequencies (about 30kHz and 50kHz).

The receiver block diagram appears in Fig. 2. The photocell is a silicon phototransistor which, for the present application, gives a good compromise between sensitivity and switching speed. The output signal is only likely to be in the region of a few millivolts peak to peak, and an amplifier is used to boost this by about 40dB (100 times). A trigger circuit is used to provide a squarewave output to drive the demodulator circuit.

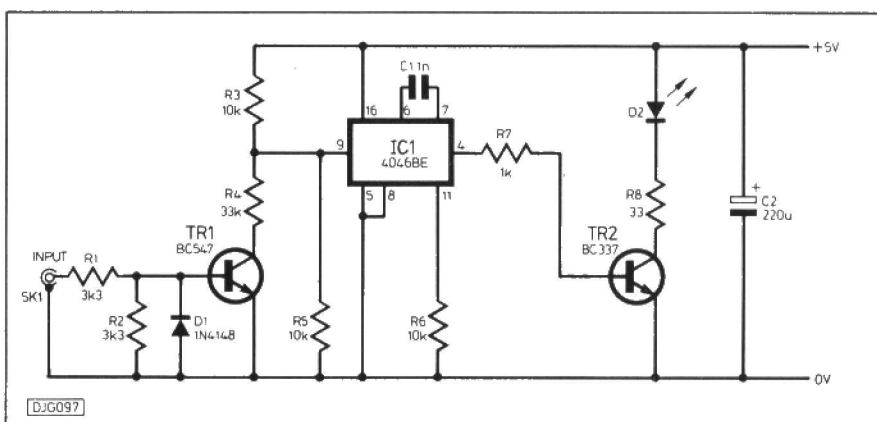


Fig. 3. Transmitter circuit diagram

It is the control voltage that is required in this case, since it switches between two potentials as the input signal switches between its two carrier frequencies. A buffer stage is used to ensure that there is no significant loading of the control voltage, and a second lowpass filter then removes most of the ripple content on the signal. The first lowpass filter provides only a relatively low level of smoothing as it must enable the VCO to rapidly track the input signal with minimal overshoot. The smoothed output voltage is only a few hundred millivolts peak to peak in amplitude, and this is boosted to normal RS232C levels (about plus and minus 12 volts) by a

emitter switching transistor which drives l.e.d. D2 at a current of about 80 milliamps. The output waveform of IC1 is roughly square, and this gives an average l.e.d. current of about 80 milliamps. The choice of l.e.d. is crucial in this application where high efficiency is essential if the system is to function at all. Using standard l.e.d.s the link would almost certainly fail to operate even over short distances. The specified l.e.d. is a "superbright" type which uses a combination of high efficiency and a lens which provides a narrow angle of view (plus and minus fifteen degrees). The typical light output at a current of 20 milliamps is 250mcd, which compares with about 2mcd for a

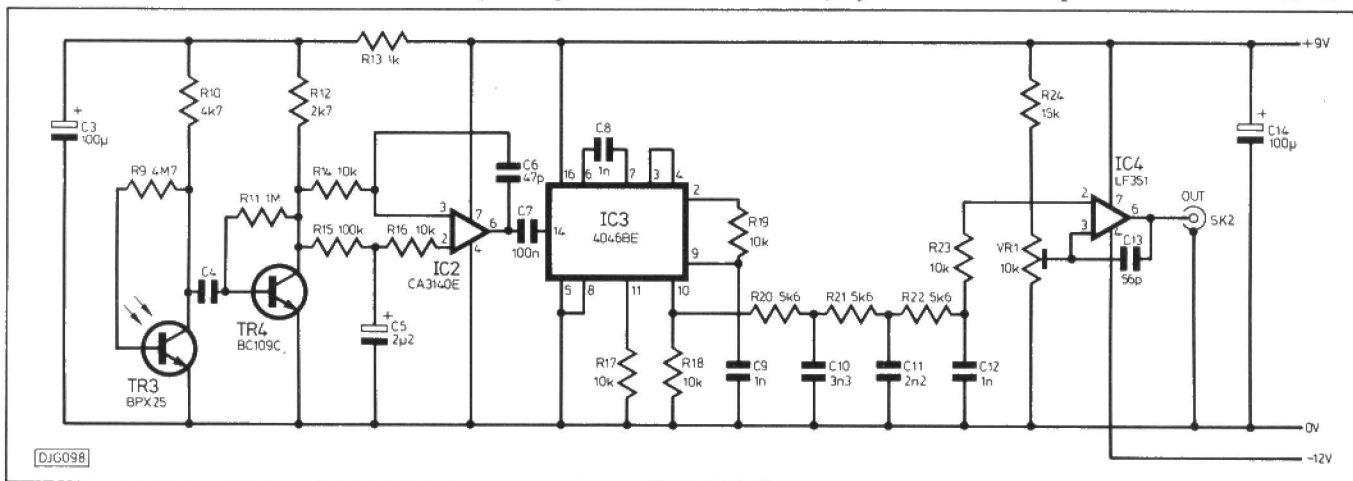


Fig. 4. Receiver circuit diagram

A phase locked loop demodulator is used, and this has the familiar phase comparator, lowpass filter, and VCO. The phase comparator and lowpass filter produce an output voltage which is dependent on the relative frequency and phase of the input signal and the output of the VCO. With the VCO at a higher frequency, or leading-in phase, this voltage falls—with the VCO at the lower frequency, or lagging-in phase, it rises. As this potential acts as the control voltage for the VCO a negative feedback action results in the VCO being locked onto and in phase with the same frequency as the input signal.

voltage comparator circuit. The reference voltage is adjustable, and to give an undistorted output waveform it must be set midway between the voltage limits of the input signal.

TRANSMITTER AND RECEIVER CIRCUIT

The full circuit diagram of the transmitter unit appears in Fig. 3.

The VCO is based on IC1 which is a 4046BE CMOS phase locked loop. In this case only the VCO section of the device is utilized and the other sections are totally ignored. TR2 is a common

standard 5 millimetre diameter l.e.d.

When the input signal is negative, TR1 is cut off and R3 plus R5 bias the control input of IC1 to half the supply voltage. This gives an output frequency of approximately 50kHz. TR1 is switched on when the input signal is positive, effectively shunting R4 across R5 so that the control voltage is reduced, and the output frequency is shifted down to about 30kHz or so.

Although significantly more complex than the transmitter, the receiver circuit (Fig. 4) is nevertheless reasonably simple.

Continued Next Month

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FAMILIAR FAMILY FUNCTIONS

BY R.A. PENFOLD

*Bigger, better, more efficient and more powerful –
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Most of the projects published in PE employ LS TTL or standard CMOS. There are new alternatives which should be looked at more closely.

LOOKING through some of the larger electronic component catalogues, one can hardly fail to notice the steady increase in the number of logic integrated circuits available. This is due in part to the introduction of new devices to satisfy the demand for even bigger and better components, but in the main it is due to the infusion of new families of logic device. In the early days of logic integrated circuits there were various types on offer, including RTL (resistor-transistor logic), DTL (diode-transistor logic), and TTL (transistor-transistor logic) types. It was the TTL variety which quickly came to dominate the scene, and despite the advent of a range of CMOS devices with their certain advantages, TTL devices still overshadow the competition. However, the original devices, although still in widespread use, have taken something of a backseat with various 'improved' versions vying to take over.

The original TTL family, although in most respects better than its initial rivals, was not without its shortcomings, and was not popular with all users (myself included). The main problem with these devices is their power requirements. A supply voltage range of 4.75V to 5.25 volts is not too restrictive for equipment which is to be mains powered, but is awkward for circuits that are intended for battery operation. Not that battery power for TTL based circuits is a very practical proposition anyway, with the more simple devices consuming a supply current of about 20 milliamps, and the more complex types requiring around 100 milliamps and operating quite warm. Even a quite modest circuit would run all but the largest of batteries flat within a few hours, and a complex circuit would require a large mains power supply capable of delivering several amps.

There are other, more minor problems, such as a lack of immunity to noise spikes on the supply rails and the consequent need for judicious use of

supply decoupling capacitors, but it was probably the supply requirements above all else which alienated many circuit designers to standard TTL logic devices.

IMPROVEMENTS

Although the internal circuits of many integrated circuits are never published by the manufacturers, those of most TTL devices are freely available, and Fig. 1 shows the circuit diagram for one gate of the 7400 quad 2 input NAND device. TTL circuits can look rather strange to the uninitiated due to the common use of multiple emitter transistors, but operation of the circuit is actually quite straightforward. With either or both of the emitters taken low, TR1 is biased hard into conduction by R1, resulting in its collector going to a low voltage and cutting off TR2. R2 then biases TR3 into conduction, but with no significant emitter current in TR2, TR4 is cut off. TR3 therefore pulls the output terminal high. With the inputs both taken high, TR1 effectively becomes a forward biased diode and R1 now biases TR2 into conduction. This results in a change of roles with TR3 becoming cut off and TR4 being biased into conduction.

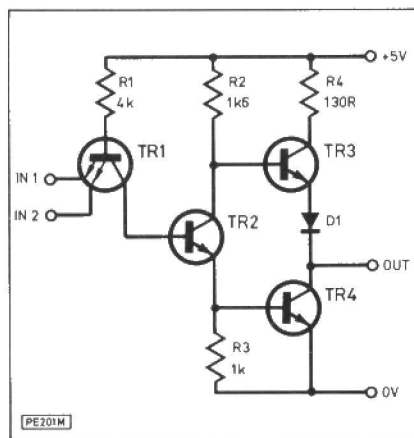


Fig. 1. 7400 gate

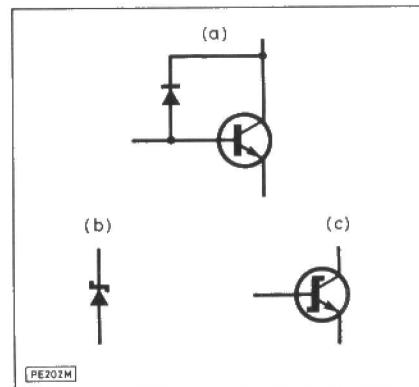


Fig. 2. Schottky addition

Although the output stage (known as a 'totem pole' type) does not consume large amounts of current when at either logic state, unlike some of the early rivals to TTL devices, the current consumption is still quite high due to the less than modest requirements of the input and driver stages. Also, during the transition of the output from one state to the other, both output transistors become switched on momentarily. This significantly increases the current consumption with high output frequencies, which is something that seems to be common to practically all types of logic device.

Obviously the currents in a TTL device can be reduced by modifying circuit values, and a low power series of devices (74L**) were produced. These never achieved widespread acceptance though, presumably due to the greatly reduced maximum operating frequency that inevitably resulted from the lower operating currents. The reduction in maximum operating frequency was more severe than one might have expected, with the 74L00 operating at frequencies of up to just 3 MHz, which compares with 35MHz for the standard TTL equivalent. This reduction in maximum operating frequency was roughly matched by the decrease in current consumption.

The 74S** series of devices have been more successful, without ever threatening to take over from the

standard type. The 'S' stands for 'Schottky', and refers to a special type of diode added to some of the transistors in the circuit. Fig. 2(a) shows the method of connection. The two characteristics which make Schottky diodes so suitable for this application are their fast operating speed and low forward conduction threshold voltage of only about 0.2 volts or less. The purpose of the added diode is to prevent the transistor from becoming biased into saturation. Biasing a transistor into saturation gives a relatively slow switching speed due to problems with charge storage that give a delayed switch-off. Much improved results are obtained if the base current is regulated so that it is only just sufficient to take the collector down to a valid logic 0 level. This is achieved by the Schottky diode, as it taps off the base current through the collector of the transistor if the transistor is driven to the point where its collector starts to fall below about 0.4 to 0.5 volts. High operating speed in the diode is essential as it must tap off the excess base current before the transistor starts to saturate, and the low conduction threshold voltage is essential as an ordinary silicon type would never become forward biased if used in this way.

Note that a Schottky diode is normally given the special circuit symbol shown in Fig. 2(b), and that the diode and transistor combination are normally given the modified transistor circuit symbol of Fig. 2(c) rather than being shown as separate components.

LS DEVICES

Standard Schottky devices achieve a significantly higher operating speed than standard TTL types, with the 74S00 having a maximum operating frequency of 125MHz as opposed to the 35MHz of the 7400. This increase in operating speed is accompanied by a small increase in supply current though. What most users require is an operating speed that is comparable to the standard TTL family, but with substantially reduced supply current. This is precisely what the 74LS** series of lower power Schottky integrated circuits provide, and it is not surprising that these have become very popular. In fact they have become the new 'standard' type, largely taking over from ordinary TTL devices in new designs.

Fig. 3 shows the circuit diagram of a low power Schottky 2 input NAND gate, and this has obvious similarities to the standard TTL circuit of Fig. 1, but it also has substantial differences. In particular,

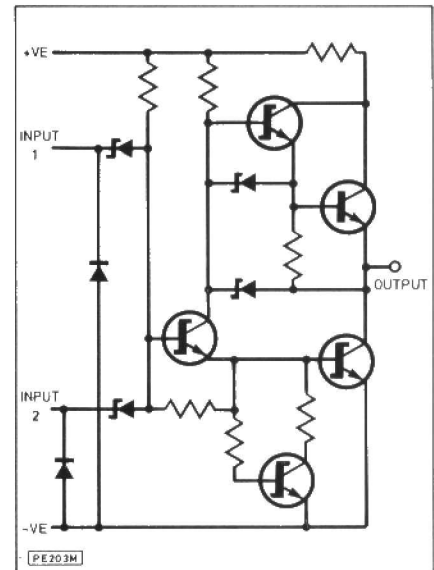


Fig. 3. LS NAND

the multi-emitter input transistor has been replaced by steering diodes, and in this respect the circuit is more like the old DTL circuits than conventional TTL types. The maximum operating frequency of the 74LS00 is somewhat higher than that of the 7400 at some 45MHz, but this is achieved at only

Table 1. Main characteristics of popular logic families (CMOS parameters are for a 5 volt supply to permit easy comparison with other families)

	Standard TTL	Standard CMOS	LSTTL	ALSTTL	STTL	HCCMOS	HCTCMOS	FACT	FAST	
Supply Voltage	5 ± 5%	3 to 18	5 ± 5%	5 ± 10%	5 ± 5%	2 to 6	5 ± 10%	2 to 6	5 ± 5%	Volts
DC Fanout	40	1	20	20	50	10	10	60	33	LSTTL Inputs
Minimum 'High' Input	2	3.5	2	2	2	3.15	2	3.15	2	Volts
Maximum 'Low' Input	0.8	1.5	0.8	0.8	0.8	0.9	0.8	1.35	0.8	Volts
Minimum 'High' Output	2.4	4.95	2.7	2.7	2.7	V _{cc} -0.1	V _{cc} -0.1	V _{cc} -0.1	2.7	Volts
Maximum 'Low' Output	0.4	0.05	0.5	0.5	0.5	0.1	0.1	0.1	0.5	Volts
DC Noise Margin (low)	0.3	1.45	0.3	0.4		0.8		1.25	0.3	Volts
DC Noise Margin (high)	0.7	1.45	0.7	0.7		1.25		1.25	0.7	Volts
Input Current (low)	40	0.3	20	20		1	1	1	20	μA
Input Current (high)	-1600	0.3	-400	-200	-2000	-1	-1	-1	-600	μA
Output Current (high)	-0.4	-2.1	-0.4	-0.4		-4	-4	-24	-1	mA
Output Current (low)	16	0.44	8	8	20	+4	+4	+24	20	mA
Temperature Range	0 to 70	-40 to +85	0 to 70	0 to 70	0 to 70	-40 to +85	-40 to +85	-40 to +85	0 to 70	°C
Typical Max. Clock Frequency	35	5	40	70	125	40	40	125	125	MHz

about one fifth of the current consumption.

There are further Schottky logic families in the form of the advanced (74AS**) and advanced low power (74ALS**) types. The advanced type have a current consumption which is virtually identical to the standard Schottky devices, but the operating speed is increased slightly, giving a maximum operating frequency of about 200MHz for the 74AS00 for example. The advanced low power type are perhaps of more interest to most users, giving a slight increase in operating speed over the 74LS** range (60MHz maximum for the 74ALS00) at typically little more than half the current consumption. Although this range looked set to oust the 74LS** range at one time, there are alternative improved devices coming along which seem to have halted the challenge.

CMOS

The logic families considered so far are all based on the original 74** line-up, and in most cases a design intended for the standard TTL range would work just as well using equivalents from one of the other ranges, with perhaps a few minor modifications being required. The original CMOS range of devices was a different concept, with a totally different range of devices which in some instances (such as the analogue switches) had no equivalent at all in the 74** range. Where there are comparable devices, such as the 7400 and 4011, these usually have totally dissimilar pinout configuration.

What makes CMOS devices so different from TTL types in use is their power supply requirements. The original 'A' series devices have a supply voltage range of 3 to 15 volts, but these are now obsolete and have been replaced by the 'B' type devices with their wider operating range of 3 to 18 volts. CMOS devices have much better immunity to noise spikes on the supply rails, and the liberal sprinkling of 100n ceramic decoupling capacitors to be found on most TTL based units are unnecessary with CMOS designs. Probably the factor which most helped CMOS devices to gain popularity is their low current consumption. In fact only minute leakage currents are consumed under quiescent conditions, but significant currents are drawn when devices are operating. In fact the current consumption is comparable to that of some TTL types when CMOS devices are run continuously at high speed. However, there are few practical designs where all the logic elements run continuously at a high frequency, and a CMOS design typically requires only a fraction of the supply current of a TTL equivalent. Another important characteristic of CMOS integrated

circuits is their extremely high input resistance of around a million megohms.

CMOS devices are based on insulation gate MOSFETs, and Fig. 4 shows the circuit diagram for a basic 2 input NAND gate. The FETs are enhancement mode types, and not depletion mode devices (like the more familiar junction gate fets such as the 2N3819). They are thus similar to bipolar transistors in that they are normally switched off and require a forward bias to bring them into conduction, but they have the very high input resistance associated with field effect devices.

The circuit is very simple in operation, and with either or both inputs taken low, TR3 and (or) TR4 will be cut off. On the other hand, TR1 and (or) TR2 will be switched hard on, and the output is taken high. With both inputs high TR1 and TR2 are turned off, while TR3 and TR4 are switched on, taking the output low. The important point to note here is that there is never any path of conduction through the circuit, with there always being at least one transistor switched off and blocking the path, and it is this that gives the negligible quiescent current consumption. Unfortunately, during the transition from one output state to the other, there is a brief period when all the transistors conduct to some extent, producing a small pulse of supply current. It is for this reason that the current consumption increases at high operating frequencies, with high frequencies giving a large number of current pulses in a given period of time.

Practical CMOS devices have protection diodes added at the input to reduce the risk of damage due to static charges. Most devices also have buffered outputs so that the output drive capability is independent of the input states. This is not the case with unbuffered types, and with the circuit of Fig. 4 for example, the high state output current capability is higher with both inputs low (and both TR1 and TR2 switched on); than it is with only one input taken low (and only TR1 or TR2 switched on). The buffered types have a 'BE' suffix, while unbuffered devices have 'UBE' as the suffix. The 'UBE' types have the advantage of lower propagation delay (the delay between the output responding to a change in input states) and are also preferable for some analogue applications. Few 'UBE' types are readily available, and in most cases there is no choice but to use the 'BE' variety.

HIGH SPEED CMOS

For all their undoubted advantages, there is one major flaw with the standard CMOS family in the form of their relatively low operating speed. This varies from one device to another, and is also supply voltage dependent, but for

simple gates is about 5MHz with 5 volt operation, improving to about two or three times this figure with 15 volt operation. Some of the more complex types can operate at no more than about 2.5MHz with a 5 volt supply.

It would clearly be very useful to have devices with the advantages of CMOS power consumption levels plus the operating speed of TTL types. The first attempts at a cross between CMOS and TTL types were actually just standard CMOS circuits but having identical pinouts to a TTL device. Thus the 74C90 was a standard CMOS decade counter with the same pinouts as the popular 7490 TTL component. This was really just a matter of making it easier for circuit designers who were only familiar with TTL devices to use CMOS types, and the 74C** range were not technically more advanced than the ordinary 40** range.

More recently there have been developments in CMOS technology which have resulted in components that rival the TTL families in terms of operating speed, but which retain some of the advantages of CMOS types. The best known of these new families is the high speed CMOS (74HC**) series. Some of these are pin compatible with the 74** range, such as the 74HC154 which is equivalent to the 74154. Others are pin compatible with the standard CMOS range, such as the 74HC4514 which is equivalent to the 4514BE.

The new 74HC** devices are produced using a existing technology, rather than radical new technology. The improvement in performance is nevertheless quite substantial, with the 74HC00 having a maximum operating frequency of 60MHz with a 5 volt supply. The supply voltage range is much reduced in comparison to standard CMOS types, but at 2 to 6 volts it is obviously far less restrictive than for TTL types. Good supply noise immunity is retained, as is the very high input resistance associated with CMOS circuits. However, whereas standard CMOS devices have only a limited output current drive capability, and can prove troublesome if mixed with TTL types, 74HC** devices have the same drive capability as 74LS** types. They also have a standardised output stage which gives identical rise and fall times, optimizing high frequency performance. Being basically ordinary CMOS integrated circuits, the 74HC** range includes equivalents for the more unusual CMOS types such as the 4046BE phase locked loop and the analogue switches.

There are two variations on the basic high speed CMOS range, the 74HCU** and 74HCT families. The HCU types are unbuffered, and are equivalents to the standard unbuffered CMOS range. Both the unbuffered types are primarily intended for use in oscillators and other

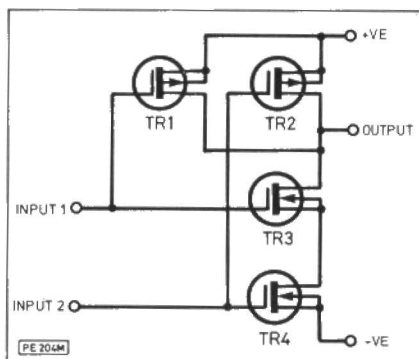


Fig. 4. 2-Input NAND

linear circuits. The HCT type have input switching levels that are compatible with the 74LS** range, whereas the HC family have normal CMOS input switching threshold voltages. The HC devices are intended for new designs, but the HCT type are aimed more at users who wish to obtain lower current consumption in existing designs, and where a mixture of high speed CMOS and TTL components are to be used. The 74HCT** series has a 4.5 to 5.5 volt supply operating range, which is far more restricted than that for other CMOS types, but is still more flexible than for most TTL families. They also have inferior noise immunity when compared with the 74HC** family.



FACT NOT FICTION

What probably represents the ultimate in current logic device technology are the FACT (Fairchild Advanced CMOS Technology) devices. Whereas the high speed CMOS family was designed as a superior replacement for low power Schottky devices, the FACT family was designed to be a rival to advanced low power Schottky devices. Current consumption is much the same as for high speed CMOS components, but the operating speed is comparable to 74ALS** devices. For example, the maximum operating frequency for flip/flops is typically 125MHz, and the 74ACT00 gate has a maximum propagation delay of 8ns. There are actually two FACT logic families, the 74ACT** series and the

74AC** series, which have TTL and CMOS input switching levels respectively. Both 'AC' and 'ACT' types operate over a 2 to 6 volt supply voltage range. We are unlikely to see anything offering significantly better overall performance than the FACT range in the near future.

EMITTER COUPLED LOGIC

Emitter coupled logic (ECL) is one of the least well known logic families, but is actually the fastest type. However, this speed is achieved at the expense of a relatively high current consumption, and emitter coupled devices also require dual supply rails. Coupled with their relatively high cost, this makes them only a worthwhile proposition where out and out speed is of paramount importance. Emitter coupled logic devices are based on the simple circuit shown in Fig. 5.

TR1 and TR2 operate as common collector (emitter follower) and common base stages respectively. When the input is taken high, TR1 is switched on but TR2 is reverse biased and becomes cut off. Taking the input low has the opposite effect, with TR1 becoming reverse biased and cut off and TR2 being biased into conduction. The high switching speed is aided by the fact that both amplifiers operate in a mode where no inversion of the signal occurs (unlike the common emitter mode), and neither device is ever driven into saturation. This simple arrangement can be extended to produce gates, flip/flops, etc., and from these basic building blocks quite complex devices can be produced. The switching speed is very impressive, with flip/flops operating at frequencies of up to 150 to 1200MHz (depending on which ECL family is used). There are no direct ECL equivalents to the 74** and 40** series, and with twin supplies being required this would not be possible. They have MC10**, MC10H**, and MC16** type numbers (the latter being the fastest).

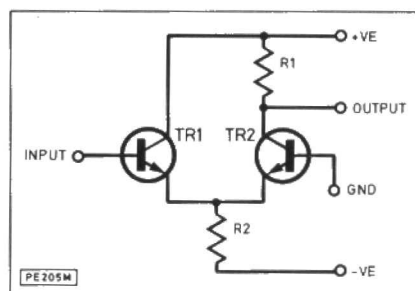


Fig. 5. ECL design

OTHER TYPES

Although we have considered a number of logic families so far, the list is not yet complete. One of the better known improved TTL families is the high speed type (74H**), which is a fast non-Schottky range of devices. These have a similar speed to the 'HC' type, but without their low power consumption and other advantages. There is another high speed logic family in the form of the FAST (Fast Advanced SchottkyTTL) range, which have 74F** type numbers. This is an improved 74S** range which achieves a 30% increase in speed, but with only about one quarter of the current consumption.

It should perhaps be pointed out that all the 74**** families are available as 54**** versions. The types having a '54' suffix are military specification devices which have a wider operating temperature range, and are not available through normal retail outlets.

CONCLUSION

Having a wide range of logic devices to choose from is in many ways a good thing, but it can result in a lot of confusion as to which family is best for a given application. In general, ordinary CMOS types are best where low current consumption is important but high operating speed is not. The 74LS** range is generally the best type where modest current consumption and a fairly high operating speed are needed. The 74HC** and 74HCT** families are attractive propositions offering both high speed and low power operation, but they are still much more expensive than the ordinary 74LS** equivalents, and are not really worthwhile unless the extra speed and power economy is really needed. It is possible to use a mixture of various types, with high speed devices only being used in circuit positions that warrant them, but some care has to be exercised to ensure that all devices are all compatible with the types they are driving, and that fan-out ratings are not exceeded. The accompanying tables give brief details of the main characteristics of several popular logic families, and should help in this respect. PE

THE FEATHERLESS WOODPECKER

BY SIMON BATTMAN

High energy pulses from Riga – a mystery story!

Mind control from the Soviet Union? Can the Schumann Resonance effect be used as the ultimate weapon? We still have no answers to the questions surrounding the most powerful transmitter on earth!

FOR a decade or so, amateur radio buffs have been aggravated by mysterious interference. Triangulation has shown these high energy pulses to come from Riga, in the North Western part of the Soviet Union. According to shortwave listeners, these infuriating broadcasts sound like a hammer. They have nicknamed them Woodpecker.

The frequencies used by international shortwave broadcasts generally lie between 4.5 and 30 megahertz. Most radio stations are grouped into bands of frequencies between these two limits. In wavelength terms, these are normally 11, 13, 16, 19, 25, 31, 41, 49 and 60 metres.

On the other hand, most aircraft and radio enthusiasts use a significantly lower range, of between 1.6 and 4.4 megahertz. For AM transmissions this can be lower still.

Our story has its origins back in early 1976, when heavy interference was first detected in both Europe and North America. Disturbances occurred between 3 and 30 megahertz. In some cases the effects were so great, that international communications on certain specific frequencies were blacked out for periods ranging from a few minutes to several hours.

It wasn't long before Western monitoring groups discovered that the offending signals emanated from behind the Iron Curtain. Protests rained on in Moscow from Britain, United States, Canada and several other countries. At first, the diplomatic niceties seemed to have little effect. Then suddenly, towards the end of 1976, the Soviets admitted they were conducting experiments likely to cause substantial interference.

As one might expect, the Soviet government did not reveal the nature of their tests, though they did agree to reduce broadcasts to shorter periods of time.

MIND CONTROL?

The lower the frequency of a radio wave, the longer its wavelength. Upon examination, waves oscillating at just a few hertz can be shown to have a wavelength the same size as planet earth. Any wave which fits exactly around our global home would set up a massive resonance, and would, therefore, be able to travel great distances. This is called the Schumann Resonance – the frequency at which the earth resonates with electrical energy.

Some time ago it was reported that the Soviets had bombarded the American embassy with high energy microwaves. These reports claimed that embassy personnel were taken ill as a direct result of the bombardment. Some have even declared that people died from the effects, while others say the transmissions were attempts at mind control. Were the early Woodpecker experiments a prelude to the microwave assaults?

In all probability, those of us outside government circles will never know the answer. Although mind control does seem a bit unlikely, it is worth noting that the Schumann Resonance itself is well within the frequency range of human brain waves. Food for thought perhaps!

WOODPECKER TODAY

Woodpecker is still transmitting today in starts and stops. There appears to be

no specific pattern to any of the transmissions, which usually last about half an hour. During this time the frequency changes – probably in order to make use of the maximum frequency and shortest possible wavelength, depending on reception conditions. But even this is by no means certain.

Transmissions tend to occur around 7 megahertz, which easily interferes with amateurs on 40 metres. It is, however, still received at 20 megahertz, as in the past.

Woodpecker is without doubt, the most powerful broadcaster on earth. It seems to be a number of transmitters, each turning out an average of 50 megawatts. The Woodpecker can generate a constant power across a bandwidth up to 200 kilohertz. To put this into perspective, the BBC's most powerful radio operates at a miserly 1/250th of Woodpecker's.

It is possible to operate in the Woodpecker band, by making use of muting circuits. These work by transmitting and receiving the gaps between the high energy pulsations. Unfortunately, as with most clever solutions, there is a draw-back. If Woodpecker decides (as it often does) to transmit on a continuous waveform, then muting circuits are about as much use to the radio ham as a car would be to a gold fish. All communications within the targeted band would be wiped out.

SPECULATIONS

It is well known that the Soviets and their allies spend millions each year trying to prevent Western broadcasts from reaching their people. It is quite possible that Woodpecker is just part of their jamming network, though it does seem like an awful lot of work for such punitive rewards. So, are there any other uses for such a powerful source of radio energy?

THE FEATHERLESS WOODPECKER

If the politicians ever feel compelled to press the dreaded red button, normal radio communications during a nuclear war would become garbled because of the intense ionizing radiation. Given that the bulk of the world's nuclear weapons are on submarines, how would a country keep in touch with its doomsday fleet?

One possible way of doing so would be to build radios which operate at very low frequencies, of perhaps just a few hertz. Such low frequencies tend to be almost totally resistant to ionizing interference, and would certainly reach nuclear subs buried deep in the world's oceans.

Many moons ago, the United States instigated such a proposal called Project Sanguine – an antenna, one million metres long, which for obvious logistical reasons would be looped.

A number of people have suggested that Woodpecker is just another version of Project Sanguine. This may well be the case, but unless the Soviets have

been experimenting with a new fangle-dangle modulation effect, the frequencies would be very low, and not in megahertz like Woodpecker. So once again we find ourselves back at the proverbial square one – speculating on the unknown.



NOT WHAT THEY SEEM

Apparently when Woodpecker is off the air, Soviet radio operators materialize, claiming to be amateurs. They ask Western radio buffs if Woodpecker is being received, and request details of time, frequency reception points and signal strength to be sent to a post box in Moscow.

There are just two other anomalies in the Woodpecker story. First, for so called amateurs the Soviets seem to be using some high calibre equipment, with power ratings of 10 Kilowatts or more. In most countries amateurs are restricted to just 400 Watts.

Secondly, they speak remarkably good English, and yet, never seem interested in the normal run of the mill chit-chat usually exchanged between amateurs. After they have discovered how well their signals are being received, they sign off into obscurity.

PE

**What are they up to?
Any ideas?**

It is possible that Woodpecker is merely an effort by the Soviets to prevent Western broadcasts reaching the USSR. Alternatively it could be far more devious – an attempt at world-wide mind control?

U S S R

Leningrad

Riga

Moscow

INDUSTRY NOTEBOOK

BY NEXUS

News from the electronics world

Further big mergers in the American electronics industry, capitalism for protection and fighting the IBM threat. Also late prizes for accidental audio designers!

SPERRY AND BURROUGHS

AFTER RCA and General Electric two more big American electronics firms have agreed to merge – Sperry and Burroughs. At the time of writing Sperry Corporation has agreed to be acquired by Burroughs Corporation for \$4.8 billion (about £3.2 billion). The deal was fixed in classical bargaining style. After initial discussions Burroughs offered \$75 per share. Sperry walked away in disgust, saying it wanted \$80. Finally they shook hands over \$76.50 per share.

What is this all about? Mainly computers. First of all there is the current recession in the US computer manufacturing industry (see July Notebook). Sperry is vulnerable because a large proportion of its total electronics turnover of \$5.69 billion is contributed by its computer business, namely \$4.2 billion. In addition the company sustained a huge loss of \$233 million on a failed farm equipment business, bringing its net profit for the 1985/86 business year down by as much as 84% to \$46.8 million (from \$286.7 million in the previous year).

FROM THE BEGINNING

Burroughs, of course, has been in computers from the very beginning. This was a natural development from its pioneering work in mechanical business machines. It was founded in 1886 as the American Arithmometer Company by W.S. Burroughs, a Rochester, New York, bank clerk. He was always in poor health and got thoroughly wearied of adding up figures by mental arithmetic day after day. He invented and patented an adding and recording machine, and this was eventually manufactured, becoming the company's first product.

In the first half of the 20th century much more advanced, electro-mechanical accounting machines were produced. Then in the second half of the century the firm – like other business machine manufacturers – went into electronic computers.

So Burroughs, like Sperry, has been affected by the US computer recession. But perhaps more important for both companies is the permanent, looming threat of giant IBM. All computer firms find it difficult to compete with the world-wide presence, huge financial resources and economies of scale achieved by IBM. It therefore makes good sense for two smaller companies like Burroughs and Sperry to merge in order to compete more effectively.

Both of them have had subsidiaries in the UK for many decades, so the new combine will not seem exactly a stranger to these shores.

JOINT VENTURE

Capitalism is all about competition, and mergers only take place for mutual protection in its jungle environment. But companies in the free market economy also get together for co-operation on a limited basis, if it suits their books, while retaining their basic independence. This is known as the joint venture. A typical case is when company A has a particular manufacturing expertise while company B has ready access to a market where A's products have not previously managed to penetrate.

A recent example is a new firm, Taiwan Semiconductor Manufacturing Company Ltd set up in the Republic of China (Taiwan). It aims to produce large volumes of low-cost VLSI devices at high yields. The country's government holds 48.3% of the equity while Philips of the Netherlands has a further 27.5%. The remainder of the shares are being made available to local Taiwanese firms.

Here the government wants to strengthen the semiconductor base of the Republic's information technology industry, while Philips wants better access to markets in the Far East. The low labour costs offered by Taiwan are, of course, well known to the European electronics industry.

In the UK a joint venture company called BT&D Technologies Ltd has been set up by British Telecom and Du Pont, makers of chemical, electronic and other materials. The new firm will develop, manufacture and market optoelectronic devices for optical fibre telecommunications and other applications. It is owned equally by the two partners.

Meanwhile, in Saudi Arabia, a consortium of five US companies led by Boeing, the Boeing Industrial Technology Group, is starting various high-tech joint ventures with local Saudi organizations. These include advanced electronics, computers and digital telecommunications. Westinghouse, ITT and Computer Sciences Corporation are the principal electronics firms and are committed for a ten-year period. Not surprisingly, there is a strong political and military element in all this.

PRIZES FOR THE PITS

The compact disc has been the saviour of the ailing gramophone record industry, so it's not surprising that its originators have now been given a nice pat on the back. I say 'now' because when the new technique of digital encoding using pits and laser reading was introduced it was intended for video discs, and, as everyone knows, these did not prove outstandingly successful in the electronics entertainment market. But the CD has redeemed all this and now the video disc has found a limited outlet in professional applications and the general recording principle as a digital data storage medium for the electronic office.

The three Philips researchers responsible for this development, Dr P. Kramer, Mr G. Bouwhuis and Dr K. Compaan, have received awards from the Rank Prize Funds for their work. These awards were established in 1972 by the late Lord Rank, the well known industrialist. Since then they have been presented to scientists who have achieved important breakthroughs in optoelectronics and in human and animal nutrition. Sir John Davies, chairman of the trustees of the Prize Funds, made the presentations to the Philips men at a ceremony in the Royal Institution, London.

INGENUITY UNLIMITED

A selection of readers' ideas

BIKE ALARM KIT

Don't mess with Jack Plug!

THIS circuit was designed as a simple but effective secondary security device for bicycles, the primary device being a lock-up chain. This is an alarm which will come into play if tampering is practised on the chain.

The circuit utilises a handful of readily available and cheap components, and is very compact when assembled. The main components are TR1, D1 and, of course, WD1.

TR1 makes up an electronic switch, which is dependent on the jack socket being either O/C or S/C. When the jack plug is present in the socket, it makes continuity between the base and supply, holding the base high and keeping the transistor hard on. When this is so, the alarm is unarmed. To

arm, the jack plug must break the base/collector circuit, turning TR1 hard off. When this occurs, the main available voltage is developed across R2 and a voltage is present at the anode of CSR1. It is triggered, and passes a current to WD1 so firing the alarm. It will conduct continuously, until the jack plug is replaced to the circuit, in which case the supply will be disabled. The jack socket is then left in place, until arming is required, once again.

The circuit may be located in the bicycle frame, and depending on the triggering transducer used, can have little or no wiring protruding from the frame.

Suggested transducers may be Mercury switches, reed switches, etc.

**Alan Crawford,
Herts.**

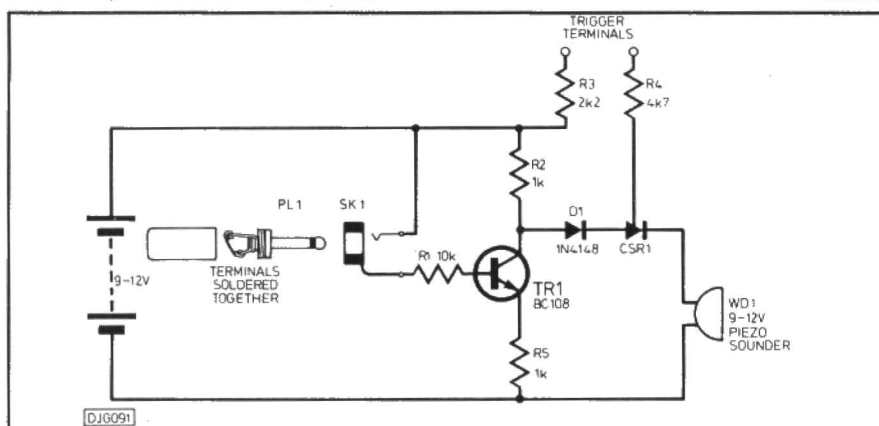


Fig. 1. Bike alarm circuit diagram

PULSE DETECTOR

It doesn't miss a thing

WHILE working on and testing computer interface circuits, it is often necessary to check for pulses lasting only a fraction of a micro-second. Even with an oscilloscope it is still hard to pick out the pulse you are interested in. Using just five components and a scrap of Veroboard, I came up with this pulse detector circuit.

The heart of the circuit is IC1 a quad NAND gate 74LS00. Two gates are wired as a flip-flop. This detects the incoming pulse and changes state accordingly. The l.e.d. is not driven directly from the flip-flop output because this would slow down its operation and the pulse might be missed. The remaining gate on the i.c. is used if

necessary to invert the pulse so the detector can detect active high or active low pulses. It is manually reset and draws its power from the circuit under test.

**S. Ling,
Scotland.**

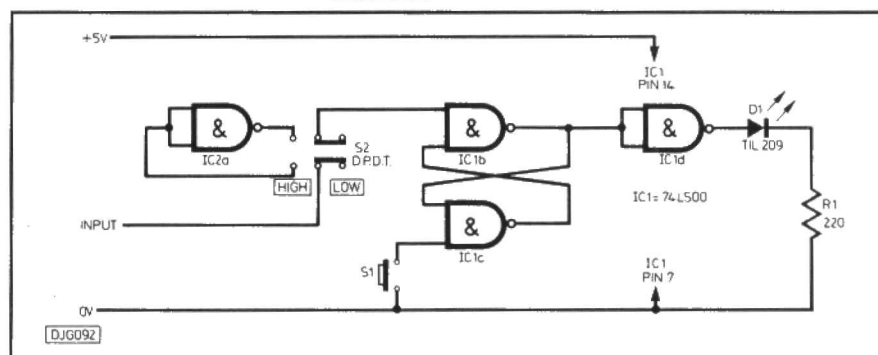


Fig. 2. Pulse detector circuit diagram

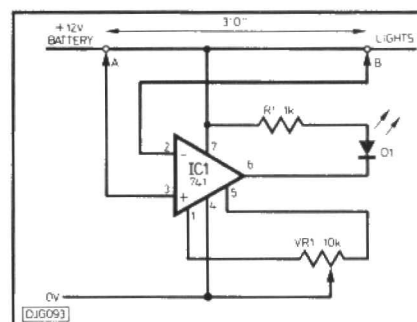


Fig. 3. Dimmer control

LIGHT SENSITIVE DIMMER CONTROL

You couldn't get a dimmer idea

I WAS looking at the various techniques of light dimmer control circuits and in particular the use of the relaxation oscillator (u.j.t.). This particular device allows a variety of add-ons to be included in the circuit for varying the brightness of the lamp.

Using a light sensitive resistor (ORP12) the light bulb can be adjusted in brightness depending on the light sensitivity of this device. If it is used to measure the light entering a room from outside, the lamp can be controlled accordingly.

Another feature which could be included is a temperature sensitive device placed near the lamp. If the temperature exceeds a preset level then the lamp can be dimmed using the same feedback technique.

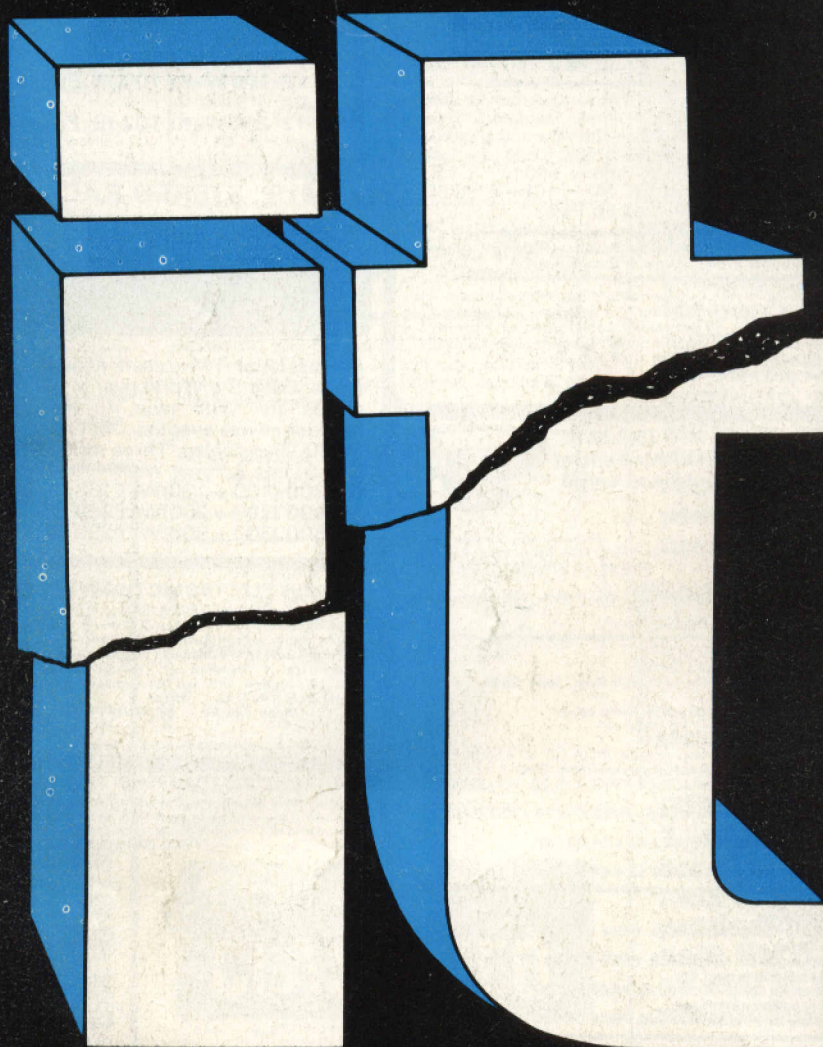
A thermistor with a positive temperature coefficient should be used.

**C. B. Herbert,
Bristol.**

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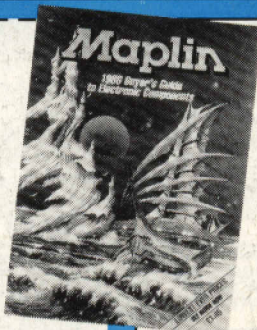
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